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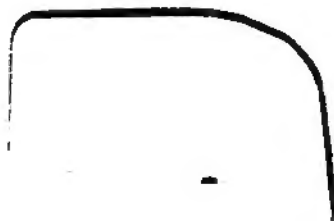
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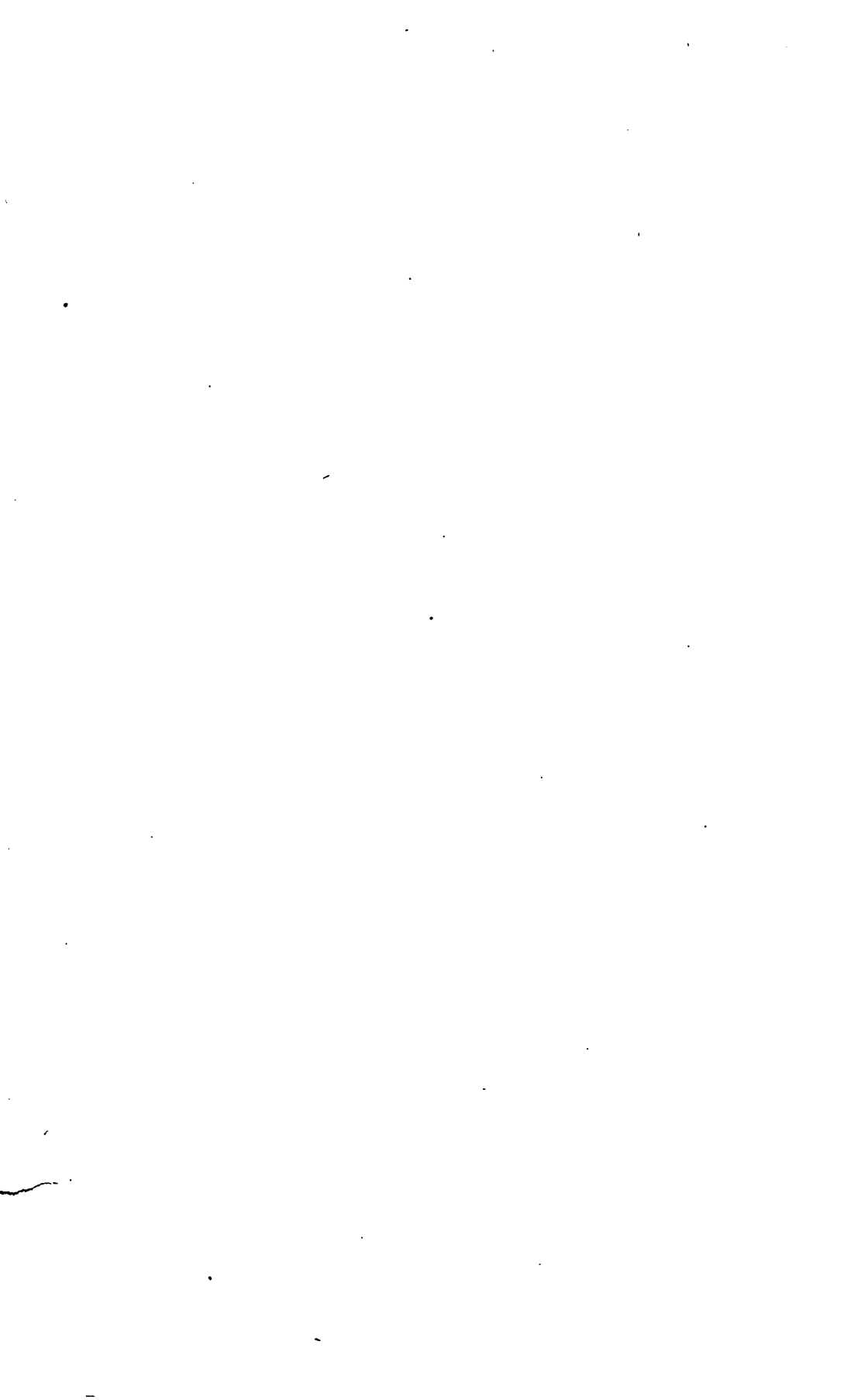
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GEOLOGY OF CANADA.

1866 1869.

GEOLOGICAL SURVEY OF CANADA.

ALFRED R. C. SELWYN, DIRECTOR.

REPORT OF PROGRESS

FROM

1866 to 1869.



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MAPS ACCOMPANYING THIS REPORT.

- ✓ 1. Geological Map of the Picton coal-field in the Province of Nova Scotia, by Sir William E. Logan, F.R.S., and Edward Hartley, F.G.S. Scale one inch to one mile. Engraved on copper and printed in colours.
- ✓ II. Geological Map of Lower Silurian rocks between the Chaudière and Trois Pistoles Rivers in the Province of Quebec, by Mr. James Richardson. Scale eight miles to one inch. Lithographed and printed in seven colors and tints.
- ✓ -III. Geological Map showing the distribution of the rock formations in parts of the Counties of Peterborough, Hastings, Addington and Frontenac, in the Province of Ontario, by Mr. Henry G. Vennor. Scale four miles to one inch. Lithographed and printed in four colors.
- ✓ IV. Topographical Sketch-Map, shewing the outlines of the coal formation in Central New Brunswick, by Mr. Charles Robb. Scale eight miles to one inch. Lithographed.
- ✓ V. Topographical Sketch-Map showing the Thunder Bay and Lake Nipigon regions; to illustrate Mr. Bell's Report. Lithographed.

GEOLOGICAL SURVEY OFFICE,

MONTREAL, *May*, 1870.

SIR,

I have the honor to transmit to you, by request of Sir William E. Logan, F.R.S., late Director of the Geological Survey, the accompanying reports of geological explorations during the years 1866, 1867, 1868.

The Reports of Mr. Edward Hartley, of Mr. H. G. Vennor and of Mr. Charles Robb, embody also some of the results of their investigations during the season of 1869, as does likewise that of Dr. T. Sterry Hunt on iron and iron ores.

I further have the honor to transmit to you a report by Mr. James Richardson of an exploration which he made last season on the north shore of the St. Lawrence between the River Saguenay and Seven Islands Bay ; and also a report by Professor R. Bell of his observations in 1869 in the Thunder Bay and the Lake Nipigon regions.

I have the honor to be,

Sir,

Your obedient servant,

ALFRED R. C. SELWYN,

Director Geological Survey.

To

THE HON. JOSEPH HOWE, M.P.

Secretary of State for the Provinces, Ottawa.

GEOLOGICAL REPORT,

For 1867-1868,

BY

SIR W. E. LOGAN, F.R.S., F.G.S.,

LATE DIRECTOR OF THE GEOLOGICAL SURVEY,

ADDRESSED

TO THE HONOURABLE JOSEPH HOWE, M.P.,

SECRETARY OF STATE FOR THE PROVINCES.

MONTREAL, 20th December, 1869.

SIR,

In May last I had the honour of presenting to the Government a Summary Report, 1868. Summary Report of the Progress made in the Geological Survey for the years 1867-1868, stating that there had just before that time been received from my various assistants detailed reports of their work, which would be transmitted after due study had been devoted to them.

Of these detailed Reports, I have now to transmit to you by the hands of Detailed Reports. my successor, Mr. A. R. C. Selwyn, the Report of myself and Mr. E. Hartley, on a portion of the coal field of Pictou, Nova Scotia; that of Mr. J. Richardson, on the Lower Silurian rocks occupying the south side of the St. Lawrence, between the Chaudière and the Rivière du Loup, in the Province of Quebec; that of Mr. H. G. Vennor, on the Laurentian rocks of the counties of Addington, Hastings and Peterboro, in Ontario; that of Mr. C. Robb, on the deposits of a region comprising chiefly the counties of York, Carleton and Victoria, in New Brunswick; and the Report of Dr. T. Sterry Hunt, on various points of geological and chemical economics.

To these Reports are added one by Mr. R. Bell, on the rocks of those islands of the Manitoulin group which are situated to the west of the Grand Manitoulin. This Report embodies the results of an exploration made in 1866, the mention of which was accidentally omitted in the Summary Report.

GEOLOGICAL SURVEY OF CANADA.

REPORT

A PART OF THE PICTOU COAL FIELD, NOVA SCOTIA.

It has already been stated in the Summary Report of May last, that the Pictou coal field to which the time of Mr. Hartley and devoted in 1868, was that which lies southward of New Glasgow extends several miles on each side of the East River; and that examination of the west side was wholly committed to Mr. Hartley, on the east side was undertaken by myself. During the season it passed however, Mr. Hartley has added many facts to those collected by myself on this side, and these will now be given by my own.

There are several important collieries in active operation near New Glasgow, on the west side of the river; and it will be observed by Mr. Hartley's report that he has had to thank the managers of these collieries for assistance they universally afforded him in facilitating his pointing out facts of interest, and supplying him with plans of underground excavations and topographical details on the surface. I press my obligations also to many persons for information, and documentary, on the east as well as the west side of the river. Among them are Mr. J. B. Moore, Mr. J. P. Lawson, Mr. J. Burton, Mr. L. R. Kirby, Mr. Alex. McKay, Col. R. B. Ross, and Mr. J. R. Jackson. Mr. J. Rutherford, the Provincial Engineer, Mines, amongst other important information, obliged us with descriptions of the boundaries of the various coal areas which have been granted by the Provincial Government; Mr. W. A. Hendry, Deputy Registrar of the Crown Land Department, was so kind as to present us with a printed map shewing the positions of these areas and their proximity to some of the topographical features of the country, and Mr. Hendry supplied us with chain measurements of some of the roads and we are indebted to Mr. Jno. Weir and Mr. Alex. McBean, practical men, for pointing out to us various local facts of an important nature with which they had become acquainted in the course of their work. Mr. Thos. Lawther, by permission of Mr. Daniels of the Geological Survey, supplied us with information of the same kind, and all the inhabitants of the country were found to be most ready to assist us in as far as they could.

The nature of this part of the Pictou coal field is of a very complicated character. While it is much covered with drift, it is disturbed by

undulations and broken by important faults, and to acquire even a proximate knowledge of the arrangement of its strata it was found necessary to measure, by compass and pacing, almost all public and private roads, as well as footpaths and streams. In constructing a map of the district, these have been kept in place by their relations to such of the straight boundary lines of the areas as we have had an opportunity of following; which lines, as given by Mr. Rutherford, have been assumed to be correct both in bearing and length. We have taken the coast and the navigable parts of rivers, as given on the Admiralty charts; and with a view of further binding our work together, Mr. W. B. Leather, C. E., was employed to measure, by theodolite and chain, a line from the East River to Sutherland's River, the direction being from the New Glasgow bridge on the former, by the old Merigomish road over Fraser's Mountain, to the lowest bridge on the latter. Mr. Leather has further assisted us by furnishing other lines, which he has had occasion to measure by theodolite, on both sides of the river. From these elements we have endeavored to construct a map on the scale of twenty chains to an inch. This may be presented at some future time; in the meanwhile its place is supplied by a plan on the scale of an inch to a mile, for the purpose of explaining the structure.

Measurements
by Mr. W. B.
Leather, C.E.

In the limited district in which we have worked there appear to be rock masses of four distinct horizons, more or less proximate. These are in ascending succession:

- | | |
|---|--------------------|
| 1.—Conglomerates, quartzites and compact slates, (Devonian.) | |
| 2.—Greenish-gray and red sandstones, with
conglomerates and impure limestones. | } (Carboniferous.) |
| 3.—Red coarse conglomerates. | |
| 4.—Productive coal measures. | |

1. CONGLOMERATES, QUARTZITES AND COMPACT SLATES.

On the east side of the East River, about four miles southward of New Glasgow, there rises a hill which runs eastward to Sutherland's River, and is transversely cut into two parts by the valley of McLellan's Brook. Of these the western is called Weaver's or McGregor's Mountain, while the other is termed McLellan's Mountain. Rocks of the series about to be described probably compose both hills, but it is in the last named that they have been observed by me. No exposure has been met with which gives all the members of the series in regular succession, nor is it certain which is the upper and which the lower part of what has been examined, the dip being always very obscure. On the north flank of McLellan's Mountain there is met with, belonging to this series, a dark leek-green slate, in some places compact, as on the south side of St. Mary's road, about 750

Pre-carboniferous rocks.

McGregor's
Mountain.
McLellan's
Mountain.

Green slates.

At the western end of McLellan's Mountain, near the residence of Mr. Robert Campbell, much of the rock is a dark gray or blackish fine grained grit, with a rough exterior and trappoid aspect; while some of it is a fine grained pistachio-green altered sandstone, with a ragged earthy fracture and gritty surface. Associated with this is a mottled green and flesh-red felsite, holding epidote, and a granular feldspathic rock, opaque white and crumbling in weathered parts, while it is much veined with white quartz.

Beyond this, southward, the rock becomes a coarse conglomerate of a mottled red and green, in some parts reddish-black, and chocolate-red in others. Some of the inclosed masses are six inches in diameter, composed of moderately coarse grains of a reddish and white feldspar and translucent quartz, with brilliant points, which seem to be micaceous specular iron ore. Some of the pebbles weather to a brick-red and orange-vermillion, very brilliant when wet. The whole rock is cracked in all directions, in fact brecciated. The sides of the cracks and the surfaces of some of the quartz pebbles are unctuous from a coating of specular iron ore. Some of the cracks shew slickensides, and some are filled with a brown manganesian powder.

Not only was this conglomerate brecciated, but so was every mass of all the series wherever met with, and to such an extent that, after hundreds of attempts, not one specimen could be dressed into an oblong shape of four by six inches, some blow of the hammer always shivering it in unexpected directions into irregular fragments, from concealed cracks.

In the locality last named, the coarse brecciated conglomerate is followed on the south side by a south-dipping band of limestone, which has been quarried for 120 paces on the strike, near the house of Mr. Alex. Fraser. The limestone exhibits fossils, one of them being *Spirorbis carbonarius*, and belongs to the succeeding series; and there may be some doubt whether the coarse conglomerate should not be classed with it. But including this conglomerate, the older rocks have here a breadth of 650 yards, and are limited on the north by the productive coal measures, dipping northward.

No evidence was observed by me, on McLellan's Mountain, to shew to what epoch these older rocks belong; but masses somewhat similar are noticed by Mr. Hartley on the west side of the East River, in a position where they have been mentioned in his *Acadian Geology* by Dr. J. W. Dawson, who considers them to be of Devonian age, and on his authority they will be so distinguished.

2. GREENISH-GRAY AND RED SANDSTONES WITH CONGLOMERATES AND IMPURE LIMESTONES.

This series of deposits appears to constitute a part of those which in his classification of the section examined by me at the Joggins, on

Farther up the brook, about thirty-three chains in a straight line, there occurs another calcareous band, which, with its associated strata, dips S. ^{Limestone Mc-}
^{Lellan's Brook.}
 1° E. < 44° - 54°. A descending section at the spot is as follows:

	Ft.	
Red sandstone of free grit, interstratified with layers of red shale.....	15	Red sandstone.
Red sandstone of a free grit.....	15	
Red sandstone interstratified with thin bands of gray limestone, weathering to a straw-yellow.....	9	
Gray limestone with interstratified yellow-weathering calcareous layers.....	4	
Gray compact limestone with a conchoidal fracture.....	8	
Red sandstone and red shale.....	45	
	<hr/> 96	

Though no fossils were observed, it is not doubted that these strata are Millstone Grit; but it is not so certain with what series to class the rocks between this calcareous band and the one farther down the stream. Of these intermediate rocks there are three exposures, with intervals of concealment. They all consist, more or less, of a brecciated red and green coarse conglomerate, similar to that north of the limestone near Mr. Alex. ^{Brecciated red and green con-}
^{glomerates.}
 Fraser's. Some of the inclosed masses are a foot in diameter, and among the smaller masses was observed one consisting of reddish orthoclase feldspar, with cleavable faces of an inch in diameter. Some parts of the exposures consist of red jaspery, fine-grained, argillaceous sandstone, harder than the usual strata of the Millstone Grit series, and others appeared to be a jaspery slate. The brecciated character of all these exposures makes it extremely difficult to determine the dip; but that of a bed of slate within seven chains of the more northern band of limestone seemed to be N. 87° E. < 87°. If the brecciated rocks between these limestones, and the brecciated conglomerate north of the limestone near Fraser's both belong to the Devonian series, there would appear to be a dislocation running along the valley of McLellan's Brook in this part, the conglomerates of the brook being more to the south than those near Fraser's.

At a bridge about a quarter of a mile above the southern band of limestone, red sandstones of a free grit, computed to be about eighty feet thick, and belonging to the Millstone Grit dip N. 61° W. < 20°, and show the irregular arrangement of the strata.

In the already mentioned triangular area of this formation, which is overlooked by Fraser's Mountain, the most continuously exposed mass of strata observed was in the channel of Pine-tree Brook, between the property of Mr. James A. Fraser and Pine-tree Gut. The total thickness of this mass may be about 1,000 feet. The lower part appears to be a greenish-gray sandstone of a grindstone grit, interstratified with several bands of nodular limestone, by the people of the country, from its impurity, called *bastard limestone*, none of which appeared to be fit for burning. There ^{Pine-tree Brook.}
^{Impure lime-}
^{stones.}

OGICAL SURVEY OF CANADA.

ed, in concealed intervals, some bands of red
ions of these were observed.

lower part, an exposure on Mr. Jas. A. Fraser's
between two bands of impure nodular limestone,
the lower about eighteen inches and the upper
ncluded 270 feet of greenish-gray freestone of an
or building purposes. The rock appears to be
f whitish quartz and whitish feldspar, with small
a black colour, the composition of which is
beds are marked by circular spots of different
eter, which appear to be sections of sub-globular
leal of calcareous matter. These are of a lighter
ng stone, and though much harder, yield more
wer of the weather, and therefore present slight
rever several small spots are together, give a
face. The proprietor calls them *bulls' eyes*. In
calcareous band a sink-hole was observed, the
dry, appeared to be lower than the level of the

down the brook there is another exposure about

It consists of the same sort of greenish-gray
kness of about 130 feet is surmounted by another
limestone of eight inches, supported by a couple
calcareous sandstone, similar in aspect to the
s. Farther down the brook, and about 100 feet
re is another mass of greenish-gray freestone of
has been quarried, to a small extent, for building
ese beds, making about 600 feet, have in the
alf a mile a pretty regular average dip of N. 20
breadth of about thirteen chains.

s brook with Pine-tree Gut, on the left side of the
Pine-tree Bank, a wooded cliff of about fifty feet
e base about fifteen feet of gray freestone in mas-
to five feet thick. A quarry has been opened
ve the level of the water. The quarry stone has
ere are eighteen inches in the middle which would
ile the remainder would furnish building stones
the cliff above this, thick bedded red sandstones
d red shale or marl and red flaggy sandstones

At the edge of the cliff, a few feet above this,
ome by Mr. J. Weir a layer of about an inch
osed might be a coal seam; but observing it had
dstone, without any indication of *Stigmara*, a

close examination shewed that it was only a layer of drift plants, the bark of which had yielded the coal. A band of impure nodular limestone was obscurely seen above it. The dip is here N. 33° W. $<14^{\circ}$. Drift plants.

What is supposed to be a continuation of the gray freestone at the foot of the cliff, occurs about twenty-five chains to the eastward, on the telegraph road, at the bridge over the south branch of the brook, where a flagstone quarry, formerly worked, became covered up in the construction of the road. A bed of impure nodular limestone underlies the rock a few feet, and it appears probable that the old quarry here may occupy the same horizon as that at the summit of the series of beds already described further up Pine-tree Brook.

North of the old quarry, and eighty or a hundred feet above it, the interval being made up apparently of the red rocks of the upper part of Pine-tree Bank, and additional strata of the same character, another band of greenish-gray freestone, fit for building purposes, occurs on the land of Mr. J. Weir. It is probably between twenty and thirty feet thick, and is succeeded by red sandstones and shales, which occupy the channel of Pine-tree Brook up to the dam of Weir's mills. These red strata, about 200 feet in thickness, are succeeded on the road, close by the mill-pond, by a few feet of greenish-gray sandstone, with another band of impure nodular limestone. The whole series of strata thus described on the lower part of the brook, occupies a breadth of about twenty-eight chains, with an average dip of N. 23° W. $<12^{\circ}$, giving a total thickness of about 400 feet. Pine-tree Brook.
Weir's mills.

Proceeding westward, these upper strata gradually assume a dip eastward of north, and at the distance of about a mile in a straight line from Weir's mills, some of the red sandstones are seen on the telegraph road, dipping N. 7° E. $<31^{\circ}$, conforming well with the lower mass of strata in the vicinity of Mr. J. A. Fraser's, the breadth they occupy being somewhat diminished from the increase of slope. Here the upper beds come close upon the flank of Fraser's Mountain, composed of the conglomerates of the third series, towards which they dip all the way to New Glasgow. On Mr. A. McGregor's land, one of the bands of impure nodular limestone is seen at the foot of the hill, about eighteen chains north-eastward of the telegraph road, and the conglomerates of the hill crop out only a short distance north of it. A. McGregor's
impure lime-
stones.

Farther westward, much drift covers the surface, but within a mile of New Glasgow the presence of red sandstone was ascertained by Mr. J. P. Lawson in a trial-pit sunk twenty-nine feet through red clay, about thirty chains north-eastward of the old straight road running S. 63° E. from the Scotch Church. About twelve chains on the same side of this road, but more than a quarter of a mile nearer the church, greenish-gray freestone, in a shattered condition, occurs. It is overlaid by a band of impure nodular limestone, and at the junction there is a layer holding drift plants, Trial-pit on red
sandstone.

GEOLOGICAL SURVEY OF CANADA.

Talamites cistii. But this exposure is on the south side of the big triangular area, which comes to a point where another shattered exposure of the same freestone was met with at the foot of the rising on which the house of Mr. J. Jack is situated.

On the south side of the triangle, upwards of a mile from the apex, still a shattered exposure of the greenish-gray freestone occurs, where this triangle crosses the telegraph road. After an interval of about a three-quarters, the next observed indication of the strata on this side is near the house of Mr. Murdoch Ross, where red sandstones are exposed on an uncertain dip. Farther on, red arenaceous strata were met by Mr. W. Love in sinking a well near his house. Red sandstones are also seen on what is called the Pent road to the Marsh, at the foot of the road leading from the house of Mr. Alexr. Fraser; but here also the dip is obscure and the dip uncertain, and it is only on approaching the River, near Ross's bridge, that the dip can be clearly made out. In natural exposures, though the occurrence of red sandstones is well known in various trial-pits sunk on the St. Lawrence area by Mr. Ross.

At Ross's bridge the following descending section occurs, the upper part being above the bridge and the lower exposed in a cliff immediately

	Feet.
sandstone.....	50
rocks concealed.....	90
red brownish-drab sandstone.....	60
pink-red sandstone.....	60
red greenish-yellow mottled sandstone.....	180
A conglomerate, with pebbles of a whitish quartzite and greenish argillaceous sandstone, spangled with small flakes of mica; all the pebbles are green externally. This layer is of varying thickness, from three inches to.....	
shale.....	1
sandstone.....	■
shale.....	■
crumbling sandstone in thin bands, separated by green shale or more crumbling sandstone.....	2
sandstone and red shale.....	■
pink sandstone mottled with green and red.....	16
red green mottled sandstone.....	14
pink sandstone mottled with red.....	4
sandstone.....	9
shale.....	■
sandstone.....	■
sandstone.....	6

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the strata occupy a breadth of nearly a quarter of a mile, with a dip on an average, is S. 23° E. < 24°, and the same attitude may

extend some distance farther down Sutherland's River. The dip is the reverse of that at Weir's mills, and between these places there must thus be at least one anticlinal form, and possibly more; but whether any rocks lower than the Carboniferous are brought to the surface in the interval has yet to be ascertained. Anticlinal.

3. RED COARSE CONGLOMERATES.

At the bridge of New Glasgow is exposed a series of conglomerates, New Glasgow conglomerates. which, in general colour, are between a brick-red and chocolate or Indian-red, and whose inclosed masses, varying from the smallest pebbles to boulders of two feet in diameter, are, for the most part, unmistakably derived from the red and greenish-gray sandstones, red shales and impure nodular limestones of the rock last described, some of them containing the same vegetable organic remains. With these pebbles and boulders are associated a few from the rocks still lower down. The whole are inclosed in a matrix of the same mineral character, constituting an argillo-arenaceous cement, which is also calcareous, and in the interstices of the boulders and pebbles is often observed a network of white calc-spar aiding to keep them together. There are interstratified in the rock, bands, from a few inches to several feet in thickness, of fine red sandstone and red shale, which serve to give assurance of the dip, and these occur at such distances apart as to render the conglomerate beds thick and massive, their transverse measure varying from ten to some times nearly 100 feet.

To this rock Dr. Dawson has given the name of the New Glasgow conglomerate. From a point a short distance above the bridge, to one much farther below, these conglomerates have a breadth of very nearly a mile, with a dip, which on the average is N. 3° — 13° W., with a slope gradually diminishing from 50° in the lower to about 30° in the upper part, and giving a total thickness of about 1,600 feet. As already indicated, this Thickness. great mass of conglomerate composes Fraser's Mountain, towards the south flank of which, presenting the outcrop escarpment of the inferior part, the red and gray strata of the Millstone Grit dip in such a way as, without other evidence, to induce the supposition that the one series overlies the other conformably. But on the west side of the East River Mr. Hartley has evidence to show that there is a want of conformity, at least in some places.

Three miles eastward of New Glasgow these conglomerates have a breadth, between their base, east of the house of Mr. A. McGregor, and their summit, on a property formerly belonging to Mr. William Fraser (Moose) of about fifty-four chains, and they are here immediately and conformably overlaid by the following ascending section: Moose Fraser's Concretionary limestone.

GEOLOGICAL SURVEY OF CANADA.

	Fl. in
e which has been quarried for burning.....	20 0
sealed.....	10 0
lightly calcareous sandstone.....	5
concretionary limestone, the surface of which presents con-	
botryoidal thinly laminated concretions, with grayish and	
y in the interstices and inequalities.....	10
clay.....	8
etionary limestone, with concentric botryoidal laminae as be-	
.....	1 0
limestone.....	1 0
mottled clay, resembling fireclay.....	1 4
sandstone.....	1 8
.....	6
aceous limestone, holding abundance of <i>Spirorbis arctica</i> *	2 2
spotted, slightly argillaceous sandstone.....	1 0
sealed, including several feet of underclay.....	24 0
ck carbonaceous shale, including about eighteen inches of	
l at the bottom, which used to be mined by Mr. W. Fraser, for	
use of burning the limestone in the lower part of the section	4 5
	69 0

These strata is N. 10° W. <47°, and very nearly on the
d give, they are again met with on a brook on the property
Small, on the road to Little Harbour, Merigomish. The
is much as three miles from the other; but the botryoidal
limestone layers in both are so peculiar and so strikingly like
and in their relation to an overlying seam of coal, that no
entertained of their equivalence. At Mr. Small's the dip

w species, obtained by Mr. Hartley, who, with Dr. Dawson and
e locality in August, 1868, and the following is a description of it,
Dr. Dawson. The figure is magnified thirteen diameters, the natural
at a.

Spirorbis arctica.

l; whorls four, the first three regularly spiral, and somewhat close, the
gular; cross section circular; shell thin, with delicate tubular struc-
han in *S. carbonarius*; surface uneven, with obscure wrinkles on the
microscopic lines of growth on earlier whorls; apex flattened for attach-
d only; length 1-10 to 1-8 inch (about 8 millimetres.)

of this limestone is about N. 23° W. <9°. The underlying conglomerate was not exposed; but there is no reasonable doubt of its occurrence beneath, and I have no evidence yet to shew that the mass is here of less volume than farther to the west.

The calcareous band with which these concretionary limestones are associated was not observed above the conglomerates on the East River, but immediately north of the position where they terminate, on the east side of the stream, after a concealed interval of 200 paces, they are succeeded by whitish sandstones, dipping north at an angle of 16°, which, a little way on, is reduced to 8°, and this low rate of inclination is maintained by the measures for a considerable distance toward Pictou, with an occasional flat undulation, reversing the dip. The apparent place of the limestone would be in the concealed interval in question.

Place of concretionary limestones on the East River.

4. PRODUCTIVE COAL MEASURES.

In the district which has engaged my special attention, the thick covering of drift so extensively concealing the strata, the dislocations which are known to affect these in some places, and the facts which suggest the probability of disturbances in others, while little has yet been revealed by crop workings, will make it difficult, for some time to come, to build up a column shewing a perfect series of the measures; and what is now offered is to be considered as only a distant approximation to the truth, to be improved hereafter as occasion may serve, and farther developments may occur.

Productive coal measures.

The most continuous exposure of the strata observed lies in the channel of McLellan's Brook, in which the rocks are bared, with short intervals of concealment, from nearly its mouth to the gap between McLellan's and McGregor's Mountains, and much farther beyond. But this section does not reach the highest strata, and some of the measures are repeated by an undulation. A portion of the beds, however, is seen nowhere else.

McLellan's Brook section.

The highest coal seam with which I have been able to connect the section, appears to me to be one of which the crop was ascertained by Messrs. McBean, on the dividing line between the first and second square mile of their three-mile area, going south-eastward, and about 250 paces from the stake at the south-western end of the line. Here there are five

The specimens described were found by Mr. E. Hartley, in limestone belonging to the coal formation, and immediately overlying the New Glasgow conglomerate. The occurrence of *Spirorbis* in this bed is mentioned in *Acadian Geology*, p. 326, but it is not distinguished from the ordinary *S. carbonarius*, from which, however, Mr. Hartley's specimens shew it to be very distinct. It is so regularly spiral that it might be mistaken for a gastropod shell; but its apex, flattened for attachment, and its microscopic structure, show it to be a worm shell. It was probably, like *S. carbonarius*, attached to submerged plants; but in the limestone above mentioned, it occurs loose in great numbers, having probably been drifted from its attachment. J. W. D.

Six-foot coal
seam.

small trial-pits and bore-holes in a distance of about eleven chains on the strike. In one of these, according to Mr. A. McBean, seven feet of coal were pierced under five feet of gravel, and in another five feet of coal under three feet of gravel, while the crop was touched in the others. The average strike of the crop is about N. 67° E., and the dip southward, but I am not able to state the rate of slope.

George McKay
four-foot seam.

A little to the west of north from this, at a distance of about twenty-two chains, reduced to a straight line, directly across the strata, Messrs. McBean sunk a trial-pit and bore-hole on the south side of St. Mary's road, not far from the house of Mr. J. McDonald (turner), penetrating, at the depth of twenty-feet, through four and a-half feet of coal. This they consider to be the same seam as that to which they sunk a pit about eighteen chains to the eastward of north from it, where it was four feet four inches in thickness, and identical with the seam which they worked by a slope about sixteen chains farther on the crop to the north-westward. This seam was previously worked by a slope about thirty-five chains still farther to the north-westward, by Mr. George McKay, for which reason it goes by the name of the George McKay four-foot seam. To the deep of McKay's slope, the Pictou Mining Company have sunk a shaft to this seam, at the Marsh Colliery, completed in October, 1868, and we thus have a section of part of the ground between McBean's six-foot and four-foot seams.

Marsh pit.

The inclination of the strata at McKay's slope is about 1 in 4, the dip at the mouth of the slope being N. 34° E., <16°; but the measures appear to spread considerably, going round by the crop to St. Mary's road, and it is probable that the rate of dip there is not more than 1 in 4½. This would give about 310 feet between McBean's six-foot and four-foot seams, and place the six-foot seam about ninety feet above the measures intersected in the Marsh pit. Combining these with what can be gathered from the Marsh Brook and McLellan's Brook, the following would be the series, as near as I can make it out from measurements by pacing, made by myself in 1868, and remeasurements by chain by Mr. Hartley in 1869.

Divisions and
sections.

For the convenience of comparison this whole series of deposits is divided into three parts or horizons—A, B, and C, and Sections under these are given in sequent numbers.

Division A, including Section 1.

Division B, including Sections 2, 4, 5, 6, 8.

Division C, including Sections 3, 7, 9.

SECTION 1. (DIVISION A.)

MEASURES INTERSECTED IN THE MARSH COLLIERY PIT.

	<i>Ft.</i>	<i>In.</i>	<i>Ft.</i>	<i>In.</i>	Measures Marsh pit.
Dark gray argillaceous shale.....	3	0			
Gray impure fireclay.....	49	0			
<hr/>					
<i>Coal.—The Captain seam.</i>			52	0	
Gray fireclay.....	4	10	3	0	Captain seam.
Gray arenaceous shale.....	3	0			
Gray solid sandstone.....	4	6			
Gray argillaceous shale.....	8	9			
<hr/>					
<i>Coal.—A seam of inferior quality.</i>			21	1	
Gray fireclay.....	4	0	1	8	
Gray arenaceous shale.....	6	10			
<hr/>					
<i>Coal</i>			10	10	
Gray fireclay.....	3	5	0	3	
Gray arenaceous shale.....	7	10			
Gray fireclay.....	2	0			
Gray strong solid sandstone.....	24	4			
Gray sandstone.....	18	6			
Gray arenaceous shale.....	8	4			
<hr/>					
<i>Coal.—The Mill-race seam.</i>			64	5	
Cannel coal.....	0	9			Mill-race seam.
Mineral charcoal mixed with coal.....	0	3			
Good coal.....	2	1			
<hr/>					
Gray soft fireclay, without divisions, holding occasional nodules of clay ironstone.....	17	6			
Gray flaggy sandstone, with thin black partings arranged in wavy layers.....	8	9			
Gray hard sandstone in one bed.....	6	0			
Gray shaly sandstone, with interstratified bands of gray hard sandstone of from one to four inches thick.....	19	6			
Dark gray argillaceous shale, with a few nodules of clay ironstone.....	11	9			
<hr/>					
<i>Coal.—The George McKay seam.</i>			63	6	
Coarse shaly coal.....	0	3			George McKay seam.
Good coal.....	3	6			
<hr/>					
			3	9	
<hr/>					
			223	7	

SECTION 2. (DIVISION B.)

MEASURES OF MARSH BROOK, FROM THE GEORGE MCKAY FOUR-FOOT SEAM TO McLELLAN'S BROOK.

	<i>Ft.</i>	<i>In.</i>	<i>Ft.</i>	<i>In.</i>	Measures Marsh Brook.
Gray fireclay, with great abundance of <i>Stigmaria</i>	3	0			
Measures not well ascertained, but supposed to consist chiefly of arenaceous shale and flaggy sandstone, with some black carbonaceous shale at the top.....	190	0			
<hr/>					
			193	0	

SECTION 3. (DIVISION C.)

MEASURES ON McLELLAN'S BROOK FROM THE MOUTH OF MARSH BROOK TO
BLACK'S MILL-SITE.Measures Mc-
Lellan's Brook.

	FT.	IN.	FT.	IN.
Gray arenaceous shales and sandstones, some beds weathering purplish-brown or reddish.....	25	0		
Black carbonaceous shale.....	8	0		
Measures concealed.....	35	0		
Gray flaggy sandstone.....	3	8		
Measures concealed.....	79	0		
Very dark bluish-gray sandstone, extremely hard and fine grained and weathering brown.....	1	0		
Measures concealed, but there appears to be sandstone in the bed of the stream.....	32	0		
Black carbonaceous shale.....	28	0		
			211	8
Coal.—A seam of hard coal but of fair quality.....				7 Small coalseam.
Very light gray fireclay, full of carbonized <i>Stigmaria</i>	2	6		
Gray argillaceous-arenaceous shales and flaggy sandstones, passing into each other.....	16	0		
Whitish-gray very compact heavy bedded freestone.....	3	4		
Light and dark gray argillaceous shales.....	4	6		
Black coaly carbonaceous shale.....	2	0		
			28	4
Coal.—The <i>Widow Chisholm</i> seam,—of fair quality but hard.....			1	0 Widow Chis- holm seam.
Yellowish-drab argillo-arenaceous very fine grained underlay with <i>Stigmaria</i>	2	3		
Dark gray compact sandstone, weathering rust-brown, full of <i>Stigmaria</i>	2	0		
Dark gray compact sandstone, weathering rust-brown, with occasional clay ironstone balls.....	3	7		
Dark yellowish-drab and brownish-drab sandstone, weathering rust-brown, in rather coarse thick beds.....	5			
Dark yellowish-drab and brownish-drab flaggy sandstones with very micaceous partings between some of the beds.....	25	0		
Measures concealed.....	14	6		
Dark yellowish-drab and brownish-drab flaggy sandstones shew- ing large casts of <i>Calamites cistii</i> , some of them four inches in width.....	2	0		
Measures concealed.....	2	3		
Dark yellowish-drab sandstones.....	9	6		
Dark yellowish-drab sandstones only partially exposed.....	49	0		
Dark yellowish-drab sandstones with false bedding and ripple- mark, and having black micaceous partings more con- spicuous towards the base.....	61	0		
Black semi-carbonaceous shale, with occasional clay ironstone balls.....	20	0		
Black highly carbonaceous shale, compact, with two sets of cleavage planes, dividing it into cuboidal blocks about one foot in diameter.....	5	0		
Purplish-gray fine grained sandstone.....	6	6		
Measures concealed.....	9	9		
Black carbonaceous shale.....	3	9		

	ft.	in.	ft.	in.
roots were observed beneath, and the shale on which it is based passes just over the top of another upright <i>Sigillaria</i> , a few feet removed on one side.....	4	0		
Gray sandstone with three inches of shale on top.....	1	0		
Gray sandstone, weathering drab; the lower and upper parts of the bed are somewhat shaly, with two inches of soft clay on top.....	2	3		
Dark gray argillaceous shale, with nodules of clay ironstone. In this bed, in the distance of twenty-five feet, there are the remains of three upright <i>Sigillaria</i> . The largest of them is about eighteen inches in diameter; a length of forty-three inches of it remains. Towards the lower part it becomes constricted and then spreads out to a wider diameter on the bed beneath. It is a sandstone cast of the plant. The remains of the other two occur at the top of the bed, in the form of sandstone cores, each of them about seven inches long, one of them being five inches and the other seven inches in diameter; the former penetrates eleven inches into the layer of sandstone above, and the hollow semi-cylindrical mould of the other is visible in the upper bed for forty-five inches, from which the plant has been removed, while at the length of twenty-four inches in the sandstone the form is cut by two inches of soft shale. All the three plants probably had roots in the same bed of shale beneath, and these may have penetrated to a bed of sandstone still lower, which is marked by the presence of <i>Stigmara</i> , but no connection could be found between these roots and the upright plants.....	4	0		
Gray argillaceous shale.....	1	0		
Gray soft argillaceous shale or clay.....	0	3		
Gray flaggy sandstones in irregular layers, with remains of prostrate plants.....	1	6		
Gray sandstone in a single bed, marked by the presence of <i>Stigmara</i>	3	0		
Gray flaggy sandstones, weathering drab, with wavy surfaces, interstratified with argillaceous and arenaceous shales....	7	0		
Gray arenaceous shale and thin sandstones interstratified with beds of dark gray argillaceous shale.....	4	0		
Gray arenaceous shale, with beds of sandstone weathering to a mottled red and drab.....	6	0		
Measures concealed, probably flaggy sandstones.....	28	0		
Gray flaggy sandstone, weathering drab, with ripple-mark.....	16	0		
Gray argillaceous shale, with layers of gray flaggy sandstone, which are wavy and weather to a mottled drab and red..	5	0		
Gray flaggy sandstone interstratified with gray arenaceous shale.	7	0		
			134	8
			924	4

Three upright *Sigillaria*.

This section terminates near the old mill-site belonging to Messrs. S. Black and A. Walker, where the measures appear to be interrupted by a fault. Evidences of a disturbance are plainly visible in the cliff overlooking the stream on the right bank; but I was unable to make out Black's mill-site.

clearly, from the cliff, which way the measures are thrown. In McLellan's Brook, all the way up to the mouth of Marsh Brook, the strata of Division C dip to the south-eastward. On the main stream, above the junction of the tributary, the same dip is maintained in the prolongation of the Marsh Brook series (Division B) to within twenty-six chains of the Fulling-mill bridge, the slope of the strata, all the way from Black's mill-site, varying from 8° to 20° . The measures are largely composed of sandstones, the strike of which is, of course, south-westward. From Black's mill-site downwards to the junction of McLellan's Brook with the East River, the measures are apparently all black shales, the chief part of them carbonaceous, giving a great thickness, with no sandstones observed. The dip of these shales is more or less north-eastward, at angles ranging from 8° to 24° . Their strike would be south-eastward, and in the prolongation of the strata in this direction, they would apparently come against the sandstones irregularly. The continuous contact of these two masses is concealed, but a line running about S.S.E. from Black's mill-site, crossing the old mill road a little north of the house of Mr. J. W. Turnbull, and coming on McLellan's Brook in the gap between McLellan's and McGregor's Mountains, would apparently have the sandstones on the east, while the black shales would be on the west, and it is probable that a dislocation, which may be called the Mill-road fault, more or less coincides with this line all the way. As no mass of arenaceous measures presenting the same characteristics as those of McLellan's Brook, is known below the black shales, the sandstones are supposed to be the higher in the series, and the dislocation would thus seem to be a downthrow to the eastward; but what may be the extent of the break, the evidence is not at present sufficient to decide.

As already stated, the south-eastward dip of the arenaceous measures on McLellan's Brook is maintained to within twenty-six chains of the Fulling-mill bridge. At this point, a seam of oil shale, formerly worked by Mr. Patrick, comes upon the brook. It is supposed to be on the same horizon as the oil shale on Marsh Brook, and the strata associated with it being more exposed on the main stream than on the tributary, we obtain additional details.

The measures here lie in the form of a synclinal, on the opposite sides of which, at the right margin of the stream, the two out-crops of the oil shale are about 200 paces apart. A fault runs in the brook in a bearing of $N. 36^{\circ} W.$ It appears to be a downthrow on the north-west side, producing on that side a greater separation of the out-crops. On the northern out-crop the evidences of the dislocation are in the middle of the stream, where black shales, on the south-east, come against sandstones on the north-west. Between the two there runs a thin vein of quartz, the underlie of which is $N. 54^{\circ} E. < 38^{\circ}$, and fragments of the quartz obtained from the vein, shewed well marked slickensides next the sandstone.

On the south out-crop, and on the north-west side of the fault, there are the remains of an old slope sunk by Mr. Patrick. The dip at the mouth of the slope is N. 22° E. < 29°; and I was informed by Mr. A. McBean that in descending this slope the oil shale maintained a thickness of from two to six inches for about twenty feet; it then gradually thickened to five feet in descending sixty feet farther, while the dip gradually became N. 67° E. < 52°; descending eight feet more, the deposit diminished to nothing; and in eight feet still further, the face of the fault presented itself, the strata becoming vertical. In the thickest part of the oil shale, a horizontal gallery was driven twenty yards to the left, and in this distance the seam thinned from five feet to fifteen inches, then again thickened and again thinned.

Patrick's slope
on oil shale.

Variation of
thickness.

From the description of Mr. McBean, and from the specimens shown me, the best and most typical parts of the oil shale appear to have a curly or felt-like structure. It is this part which varies so much in thickness, and while the bottom of the deposit remains even, the thinning arises from depressions in the upper portion, which are filled up with even layers of the more ordinary carbonaceous shale. The out-crops approach one another to the north-west, and the turn on the axis of the synclinal occurs about 300 yards from the margin of the brook. The measures associated with the oil shale on the opposite out-crops, as exposed on the brook, are as follows, in descending order, both sections belonging, of course, to the Division B:

Felt-like structure
of oil shale.

Axis of synclinal.

SECTION 4. (DIVISION B.)

MEASURES ON THE SOUTH OUT-CROP FROM THE HIGHEST BEDS SEEN ABOVE THE OIL SHALE UP
McLELLAN'S BROOK TO THE FULLING-MILL BRIDGE.

Measures on
south out-crop.

	Ft.	In.	Ft.	In.
Brownish-gray fine grained sandstone, weathering brown.....	0	9		
Measures concealed.....	4	7		
Gray compact sandstone, with wavy micaceous partings.....	0	10		
Measures concealed.....	2	0		
Dark gray flaggy sandstone, weathering brownish-gray.....	1	0		
Measures concealed.....	5	3		
Bluish-gray argillaceous shale.....	2	3		
Measures concealed.....	2	0		
Bluish-gray argillaceous shale.....	1	6		
Black highly carbonaceous shale.....	13	6		
Measures concealed.....	13	8		
			47	4
<i>Oil shale.</i> —A seam varying in thickness from one inch to eight feet			4	0
Measures concealed.....	26	0		
Black argillaceous shale.....	8	10		
Black carbonaceous shale.....	3	5		
Measures concealed.....	164	0		
			202	3

Oil shale.

	Fl.	In.	Fl.	In.	
<i>Oil shale.</i> —A seam of black highly carbonaceous shale, containing lenticular masses of a substance like oil shale, as proved in a pit sunk to by the Pictou Mining Company.....					Oil shale.
				0	4
Black carbonaceous shale.....	2	0			
Measures concealed.....	15	4			
Light bluish-gray argillaceous shale.....	1	6			
Black carbonaceous shale.....	9	0			
Measures concealed.....	46	0			
Black carbonaceous shale.....	5	0			
Measures concealed.....	17	6			
Black semi-carbonaceous shale.....	5	0			
Black argillaceous shale.....	6	8			
Black carbonaceous shale.....	5	0			
Black carbonaceous shale, very compact and tough.....	5	3			
Measures concealed.....	13	6			
Brownish-drab thick bedded sandstone, weathering rusty, with black micaceous partings.....	4	5			
Gray very fine grained sandstone, with clay ironstone balls....	4	9			
Gray very fine grained sandstone, partially concealed.....	6	6			
Very light gray fine grained sandstone, weathering rusty in the partings.....	1	4			
Gray sandstone, with black partings.....	27	6			
Brownish-drab flaggy sandstone, weathering brown.....	3	9			
Blackish-gray argillo-arenaceous shale, interstratified with light-gray arenaceous shale, with black partings.....	6	6			
Dark brownish-drab fine grained sandstone, weathering rusty...	4	9			
Dark bluish-gray arenaceous fireclay, weathering very soft in some beds.....	6	11			
			198	2	
<i>Coal.</i> —A seam supposed probable in this place.....			0	0	Supposed coal seam.
Dark bluish-gray arenaceous fireclay, partially concealed.....	7	5			
Measures concealed.....	20	0			
Gray sandstone, with black wavy micaceous partings.....	24	10			
Measures concealed.....	7	9			
			60	0	
<i>Coal.</i> —A seam supposed to be about this horizon.....			0	0	Supposed coal seam.
Measures concealed.....	80	0			
Black carbonaceous shale.....	9	7			
			89	7	
			400	10	

Both of these sections terminate at dislocations. That concluding at the Fulling-mill bridge comes against a break of considerable importance; its course appears to be N. 77° E., and it may be called the Fulling-mill fault.

The whole area of Productive coal measures belonging to that part of the Pictou field which has been under the examination of Mr. Hartley and myself, is included between two great upthrow dislocations, which may be termed the North and South faults. The former crosses the East River a little above New Glasgow bridge, where it brings the productive measures abruptly against the New Glasgow conglomerates. It thence runs to

Fulling-mill fault.

Great North fault.

AL SURVEY OF CANADA.

south side of the triangular ar
 been previously described, th
 half of the distance, and S. 68°
 sses the East River about three
 rth side of McGregor's Mountain
 out seventeen chains above the l
 h foot of McLellan's Mountain;
 chains below McPherson's bridge.
 onian rocks of McGregor's and
 f the former mountain to abut
 ring west of the Mill-road fault, a
 the higher and more arenaceous

Mill-road fault these more arenaceo
 ace between the North and South
 l in three synclinal forms, the axe
 a little more than a mile and a-h
 , running in the vicinity of Patrick'
 her a little north of the pit sunk at
 ay four-feet coal seam. There is
 ver half a mile north of the lat
 f Potter's Brook near the teleg
 the North fault. These synclin
 Marsh), and North, the Middle

ge McKay seam on the south
 George McKayslope, and its cours
 g Company's trial-pit, (thirty-six
 the crop, is about S. 62° E. But
 more southward course, and foldir
 es between the Middle and South
 Mary's road about 200 paces sout
 ald, (turner), in McBean's trial-pi
 y continuous trial-pits farther on, b
 uth-west, in what appears to be t
 -slope, about 230 paces outside
 idary, has been sunk on a coal s
 running north-westward near the

m, the thickness of this seam is th

t a triangular area of Millstone Grit r
 een the South fault and one branching
 ck shales may abut against such rocks.

inches, and the dip at the mouth of the slope, which is about four feet above the stream, is S. 16° E. $< 19^{\circ}$; but at nine feet down the slope the roof suddenly assumed an inclination of 70° . In another slope sunk at the level of the brook and a few paces to the north-east, the sudden increase of inclination occurred at a depth of about four feet; and by this it would appear that a fault is here present running about east and west, which would account for the irregularity of the strike at the mouths of the slopes. This seam is supposed to represent the George McKay four-feet seam. The dislocation may be called the McGregor fault.

On the right bank of the same brook, about a quarter of a mile further up, and a little within the south-western boundary of the McBean area, three small trial-pits have been sunk on a coal seam about four hundred paces from the south-west corner of the line between the first and second square miles. The thickness and character of the coal, I am not able to state with exactness, but the former appears to be from three to four feet, and the coal is covered by at least eight feet of black shale. The dip at the crop is S. 43° E. $< 17\frac{1}{2}^{\circ}$; but according to Mr. McBean the inclination, after descending a short distance, suddenly increases to a considerable angle, and a crack in the coal at the bend is filled with shale similar to that of the roof. If the dip of the measures to the north-west be the same as that at the crop, this seam would appear to be about 160 feet over the George McKay seam, which is about the horizon of the Captain seam in the Marsh pit.

Coal seam supposed equivalent to the Captain seam

Several trial-pits and slopes have been sunk upon the south out-crop of the Captain and Mill-race seams in the vicinity of the Marsh pit, establishing the run of these seams, and shewing apparently a small divergence from the George McKay seam, going eastward, probably from some diminution of the inclination. Proceeding in an opposite direction from the George McKay slope, trial-pits which have been sunk on the crop of this seam, as pointed out to me by Mr. Lawther, exhibit the turn of the seam upon the axis of the synclinal about thirty chains westward from the Marsh pit, and the run of the Marsh pit group of seams on the north rise is indicated first by a slope sunk by Mr. Lawson on the Captain seam, for the Merigomish Company, near the north-west boundary of their area, about twenty-two chains from the south-west corner post.

Captain and Mill-race seams.

Axis of Middle synclinal.

The coal is here three feet thick, and the dip at the mouth of the slope is S. 20° E. $< 17\frac{1}{2}^{\circ}$. This inclination continues for eighty feet down the slope, when a downthrow occurs about equal to the thickness of the coal, beyond which the inclination becomes 22° , and continues so for forty feet. In a bearing N. 67° E. from this, at a distance of about 850 paces, Mr. Lawson, by direction of Mr. Moore, has tested the whole of the Marsh pit group of seams, on a small stream which flows down the south slope of the

Captain seam, Merigomish area.

Marsh pit group tested by Lawson.

	<i>Ft.</i>	<i>In.</i>	
Cannel coal.....	0	4	Four-foot seam above Captain seam.
Mineral charcoal mixed with coal.....	1	0	
Good brilliant coal	0	8	
Coal bored through.....	1	9	
	<hr/>		3 9

The level course between the two pits is very nearly north, with a slope to the west, said to be about 1 in 6, or 9° , the low angle and irregular bearing of the dip no doubt arising from the circumstance that we are here approaching to the axis of the synclinal curve. The southern of the two pits is about 300 paces from the assumed south crop of the Captain seam; but having no means of determining the law of the curve it is not possible to calculate the vertical distance of the one seam from the other, nor to state what may be the relation of the higher one to the coal bed in the lowest position on McPherson's Brook.

Beyond McPherson's Brook the Captain seam appears to run along a dingle supplying a tributary streamlet, a quarter of a mile up which there is a red ferruginous spring,* which is supposed to give evidence of its presence at the foot of a steep rise on a farm road leading up into D. McPherson's fields on the top of the hill. Should this seam and those associated with it continue in the same course for half a mile farther, they would come against the great North upthrow fault, the effect of which, however, may possibly turn them a little south of west and continue their out-crop somewhat farther eastward; but of this there is as yet no evidence.

Somewhat over a mile south-west from the red spring, on the tributary of McPherson's Brook, and about thirty-three chains from the south-east boundary of their area, Messrs. McBean have sunk a trial-pit through eleven feet of drift and one foot of greenish-gray arenaceous shale, to a coal seam, of which the following is a section:

	<i>Ft.</i>	<i>In.</i>	
Cannel coal.....	0	1½	Lawson's trial pit.
Good coal.....	0	4	
Coarse coal and black carbonaceous fireclay.....	1	0	
Good coal of rather coarse texture.....	2	6	
Coal not so good, with hard shaly bands.....	2	6	
	<hr/>		6 5½

The crop of the seam rises in a small brook (the upper part of the Marsh Brook) about twenty feet to the south-westward, with a strike N. 37° E.; but a trial-pit sunk by Mr. Lawson on the crop about 160 paces north-eastward of the previous one, would appear to show the strike

* The proximity of coal seams to the surface is so often indicated by red ferruginous springs, that these springs, called by Welsh miners *the blood of the coal*, are sometimes taken as a guide in the search for out-crops.

	Ft.	In.	Ft.	
Light yellowish fireclay with <i>Stigmaria</i>	20	0		
Measures concealed.....	28	0		
Dark brownish-gray argillaceous shale, with six inches of black compact carbonaceous shale at the bottom, holding many well preserved scales of <i>Diplodus</i> , half an inch in diameter.....	4	0		<i>Diplodus</i> scales.
			52	
Coal—Good coal.....	0	10		
Coaly shale.....	0	2		
			1	Coal seam small
Dark gray underclay with <i>Stigmaria</i> , and bluish-gray fireclay.....	4	0		
Measures concealed.....	60	0		
Drab-gray fine grained sandstone partially exposed.....	20	0		
Measures concealed.....	30	0		
Greenish conglomerate with quartz pebbles, associated with fine grained sandstone, only partially exposed.....	30	0		Lower conglomerate.
Measures concealed.....	45	0		
Black shale, a band of which at the top is carbonaceous and is said to burn with a bright flame like oil shale.....	54	0		
			243	
Coal.—A seam reported by Mr. A. McBean to be probably here but of uncertain thickness.....			1	Reported coal seam.
Measures concealed.....	95	0		
Bluish-gray arenaceous shale.....	15	0		
			110	
Coal.—The McBean eight-foot seam.....			8	McBean eight-foot seam.
			814	

Behind the McBean eight-foot seam Mr. Lawson has sunk several trial-pits on the McBean area, and Mr. Robert Mitchell has sunk a number of others on the Mitchell and Barton area which adjoins it on the south-east. By these pits the measures have been partially tested to a horizontal distance of about fifteen chains, in which the inclination of the strata gradually increases from 33° up to 55°, while they remain very parallel to one another on the strike, and a descending section of the ground, at right angles to the plane of the beds, is as follows, as nearly as has been ascertained :

Lawson and Mitchell's trial-pits.

Steepening of measures.

SECTION 7. (DIVISION C.)

MEASURES BENEATH McBEAN'S EIGHT-FOOT SEAM.

	Ft.	In.	Ft.	In.	
Greenish-drab underclay with <i>Stigmaria</i>	3	0			
Measures concealed.....	6	0			
Yellowish-drab shaly sandstone.....	14	0			
Black and dark gray argillaceous shale.....	14	0			
			37	0	
Coal.—A seam of an inferior shaly character.....			3	0	Seam of poor coal.
Gray underclay.....	2	0			
Measures concealed.....	8	7			
Yellowish-drab shaly sandstone.....	4	6			
Black argillaceous shale.....	4	6			
			19	7	

Barton area where it seems to be interrupted by a fault, but the seam may possibly be found ultimately to be the same as that struck in Haliburton's pit on the St. Lawrence area, somewhat less than half a mile beyond, where it apparently comes against the great North fault. In the other direction from McBean's slope Mr. Lawson has sunk a series of trial-pits on the crop, tracing it in a bearing S. 37° W. for thirty-five chains, whence it gradually bends to S. 22° W. for between five and six chains farther. By this it appears that the crop runs unbroken for very nearly three-quarters of a mile on the McBean area. At the south-western end of this, however, it meets with a serious interruption in the occurrence of a great dislocation. This appears to produce an upthrow on the south side, but what the extent of the break may be has not yet been quite determined. The position of this break having been ascertained by Mr. Lawson, it is proposed to designate it by his name. In bearing it appears to be about S. 77° W., and in this direction it may have a connection with the Fulling-mill and the McGregor faults.

Crop of eight-foot seam to W.

Lawson fault.

If the measures are not interrupted by other disturbances, the Lawson fault would permit a much farther extension westward to the out-crop of the overlying six-foot than to that of the eight-foot seam, and by a series of trial-pits along the out-crop of the six-foot seam for the purpose of proving this, the increased workable extension of the eight-foot seam beneath would be proved at the same time.

If by a proper transverse examination in the vicinity of the six-foot seam this should be found equivalent to the George McKay four-foot, or any one of the Marsh pit group, it would of course be immediately inferred that the eight-foot seam will occur some 700 or 800 feet beneath the bottom of the Marsh pit, and its out-crop might thus be sought for near the mouth of the Marsh Brook.

Position of eight-foot seam on Marsh Brook

Although there are too many intervals of concealment on the lower part of the Marsh Brook, as well as between the six-foot on the upper part of the brook and the eight-foot seams, to permit an accurate comparison of details, yet it will be perceived by a reference to Section 2 (Division B), that at the depth of 789 feet beneath the George McKay seam there occur some bands of fireclay, and although no coal was seen associated with them, this would apparently be a favorable position in which a search for the eight-foot seam might be instituted. This spot is on the Pictou Mining Company's area, and the occurrence of the eight-foot seam here would establish its existence not only over the whole north-western part of the McBean area and carry it some distance on that of the company just named, but place it also under a considerable portion of the George McKay and other areas in the neighbourhood.

Red-weathering
sandstones.

In the 730 feet of arenaceous measures which have been partially examined beneath the McBean eight-feet seam, Section 7 (Division C), there occur in the lower half many bands of sandstone which weather to various tints of red, giving them externally the aspect of beds belonging to the Millstone Grit, and without careful examination they might be mistaken for such. There are beds on McLellan's Brook, in the lower part of Section 3 (Division C), which have the same peculiarity, though by no means to the same extent, the effect of the weathering being to give the surface of the rock merely a mottled red and green colour. An instance of this is very conspicuous in a flagstone quarry on the top of a narrow ridge formed by a sharp turn on the right bank of McLellan's Brook, a little above Black's mill-site; and it serves to assimilate the strata of the two localities.

Synclinal form.

Greenish con-
glomerates.

Four-feet seam.

Allusion has heretofore been made (p. 16) to five small trial-pits and bore-holes on the crop of a coal seam sunk by Messrs. McBean on the line between their first and second square miles (going south-eastward) about 250 paces from its south-western extremity. The dip is here southward; but at the extremity of the line it appears to be northward. There is thus a synclinal form in the interval; and through this interval is supposed to run the Lawson fault, throwing the measures up on the south side. In the vicinity of the stake at the extremity of the line there are obscure evidences of the occurrence of a series of greenish-grey conglomerates with silicious pebbles. These conglomerates are better seen near the residence of Mr. Alexander McLean junior, where, as I was informed, the rock was met with in excavating the cellar of the building; and it occurs in two very small ravines between 200 and 300 paces westward. Similar conglomerates in a lower stratigraphical place are well displayed near the residence of Mr. Alexander McLean senior, at the foot of McLellan's Mountain, where the rock is intersected by a mountain brook to the east of the house. On this brook, Mr. Haliburton has tested two coal seams; one above the lower conglomerates, by a trial-pit on what is said to be a four-feet seam, at the foot of the hill, and another a short distance on the rise of the hill, where a four-feet seam immediately under the conglomerates and their associated sandstones, is naturally exposed.

The dip of the conglomerates at the more northern position is about N. 48° W. < 13°; approaching the more southern conglomerates, it is about the same in direction, with an inclination of 19°, and at the out-crop, up the hill, the inclination increases to about 24°. Constructed from these elements as a guide, the following would appear to be a descending section of the ground, to which, of course, the amount of concealment must give some uncertainty:

SECTION 8. (DIVISION B.)

MEASURES INTERSECTED ON THE LAND OF MR. A. McLEAN, SEN.

	Ft.	Ft.	Measures on A. McLean's land. Conglomerates.
Greenish-grey conglomerates with silicious pebbles of various sizes up to two inches in diameter, many of them consisting of white quartz..	85		
Measures concealed.....	22		
<i>Coal</i> .—A seam of which the <i>wash</i> is seen about fourteen chains to the westward of the line of section.....		107	
Greenish-grey sandstone with much false bedding, seen about nine chains to the eastward	20	0	
Measures concealed.....	290		
<i>Coal</i> .—A seam sunk to by Mr. Haliburton, near McLean's barn, said to be		310	
Measures concealed.....	25	4	Four-foot coal seam.
Greenish-grey conglomerate with silicious pebbles of various sizes up to two inches in diameter. This is not seen on the brook but to the westward of McLean's house.....	37		
<i>Coal</i> .—A seam is supposed to be probable here		62	
Grey arenaceous underclay with <i>Stigmaria</i>	3	0	Supposed coal seam.
Greyish-drab flaggy sandstone	12		
Black carbonaceous shale	13		
Greenish-drab coarse conglomerates with silicious pebbles of various sizes up to two inches and a-half in diameter, in an arenaceous cement .	30		Conglomerates.
Yellowish-drab and greyish-drab flaggy sandstones with partings shewing carbonized plants	18		
Black carbonaceous shale	3		
Greenish-drab flaggy sandstone.....	16		
Greenish-drab coarse conglomerate, as before.....	8		
Yellowish-drab flaggy sandstones and coarse conglomerates, partially concealed	55		
Dark greyish-drab moderately thick bedded sandstone with many impressions of plants.....	5		
<i>Coal</i> .—A seam opened by Mr. Haliburton at the crop. This may be called <i>The Mountain seam</i>		163	
		4	Mountain seam.
		650	

By comparing Sections 6 and 8, it will be seen that there are two series of conglomerates in each, with no great difference of distance apart, while there is nothing in the one section seriously contradicting the other, so far as known. Immediately beneath the lower conglomerates in Section 6, the measures are concealed, and these coarse beds may extend farther down; but the change in the sediments to carbonaceous shales a little lower would make the base of the conglomerates appear to be a position in which a coal seam might reasonably be expected. The discovery of such there would cause the parallelism of the two sections to be more complete, and render a search for the McBean eight-foot seam at the distance indicated between it and the conglomerates in Section 6, a reasonable undertaking in the

Supposed place of the McBean seam.

SECTION 9. (DIVISION C.)

MEASURES INTERSECTED ON AND NEAR McLEAN'S BROOK.

	Feet. In.	Feet. In.	Measures Mc- Lean's Brook.
Light-grey very hard and tough underclay with <i>Stigmaria</i> ...	2 0		
Measures concealed	57 0		
Grey sandstone banded with dark brown streaks; the rock weathers rust-brown and holds <i>Stigmaria</i>	6 0		
Measures concealed.....	3 0		
Dark brown arenaceous shales, with carbonized impressions of <i>Cordaites borassifolia</i>	4 0		
Measures concealed.....	16 0		
Black argillaceous shale	5 0		
Measures concealed	35 0		
Grey arenaceous shales with ferruginous bands prevailing most towards the bottom, and weathering rust-yellow, while the rest of the beds weather a deep brown.....	6 0		
Dark grey arenaceous shale, with <i>Stigmaria</i> and <i>Cordaites bor-</i> <i>assifolia</i>	2 6		
Measures concealed.....	16 0		
Yellowish-drab fireclay, full of indeterminate <i>Calamites</i> casts, replaced by clay iron-stone	6 0		
Measures concealed.....	3 0		
Yellowish-drab fireclay, full of indeterminate <i>Calamites</i> casts, replaced by clay iron-stone	3 0		
Measures concealed	12 0		
Greenish-drab coarse grained sandstone, stained reddish-brown in the partings, which are full of carbonized comminuted plant-casts	4 0		
Measures concealed.....	20 0		
Light grey sandstone with argillaceous partings carrying in- determinate plants.....	5 0		
Measures concealed.....	32 0		
Black carbonaceous shale full of bivalve shells resembling <i>Modiola</i>	2 0		
<hr/>		239 6	
Coal or coaly shale.....		3 1	Small coal seam.
Measures concealed.....	10 0		
Dark brown arenaceous shales, the colour passing into black.	2 0		
Measures concealed.....	7 0		
Grey underclay with <i>Stigmaria</i>	4 0		
Measures concealed.....	120 0		
Light grey flaggy sandstone with black carbonaceous partings, holding <i>Noeggerathia</i> , casts of <i>Calamites</i> and other inde- terminate plants.....	4 0		
Measures concealed	30 0		
<hr/>		178 0	
Coal.—The Widow McLean ten-feet seam (so called.)			Widow Mc- Lean ten-feet seam.
Bad shaly coal	6 8		
Good coal	1 6		
<hr/>		8 2	
Dark grey argillo-arenaceous underclay with <i>Stigmaria</i>	1 6		
Measures concealed.....	36 0		

	<i>Ft.</i>	<i>In.</i>	<i>Ft.</i>	<i>In.</i>
Greenish-drab conglomerate with a reddish tinge, perhaps from weathering; it holds pebbles of various sizes up to two inches in diameter, many of them of white and grey quartz and some of red sandstone	3	0		
Measures concealed	90	0		
Dark grey hard sandstone in even layers varying in thickness from one quarter to three quarters of an inch; they would be well suited for the purposes of tile-stones...	30	0		
Greenish-drab conglomerate with silicious pebbles.....	1	8		
			170	0
			941	0

While the general strike of the strata associated with the Mountain four-foot seam appears to be about S. 40° W., that of the Widow McLean group is S. 8° W., and this divergence makes it seem probable that the difficulty of the search for the McBean eight-foot seam between the two will be enhanced by a dislocation, the position and amount of which have yet to be discovered. Probable fault.

The above section occupies a breadth of about 630 paces, in which the westward slope of the strata gradually increases from 80° at the summit to 58° at the base, and at a farther horizontal distance of about 280 feet across the measures to the eastward, in which the strata are concealed, there occurs an exposure of red conglomerate, more resembling beds belonging to the New Glasgow conglomerate or to the Mill-stone Grit than any seen interstratified with the workable coal seams. This mass, of which I could not determine the dip or strike, occurs on McLean's Brook, about 200 paces, following up the stream in a north-westerly bearing, from the pond of Mr. Finlay McDonald's saw-mill. From the head of the pond down to the mill there is a distance of about 200 paces in a direction nearly east, the strata in which are probably of the same character as the red mass farther up, and at the mill-dam coarse brick-red or Indian-red shales become exposed on the right bank of the brook, some of the beds of which display a few disseminated silicious pebbles of a couple of inches in diameter. Red conglomerate.

In the bed of the stream under the mill a band of limestone makes its appearance. It is obscured by the refuse slabs ejected from the mill, but up in the cliff on the left bank it is again exposed, and here it has been quarried to a small extent. The limestone is brownish-grey in colour, and holds obscure fossils, some of which are probably *Spirorbis carbonarius*. This band of limestone, which is limited on each side by coarse red shales, is eighteen feet thick, and some small portions of it seem to be made up of hard masses of limestone surrounded by greenish shale. The dip of the bed is N. 87° E. < 55°. Red shales.

About one hundred and twenty paces eastward another calcareous band runs up the cliff. It is about sixteen feet thick, and may be a Fossiliferous limestone.

repetition of the previous one, either through an undulation or a dislocation, the dip being S. 72° W. $< 86^{\circ}$. The strike in each case would be nearly north and south, but that of the strata farther down the brook appears, with many irregularities, to run more with the trend of the valley, which is nearly east. Somewhat under a mile down the valley, and about three hundred paces north of the brook, there is still another exhibition of limestone near the house of Mr. Finlay McDonald (sawyer.) Here the band is eleven feet thick, in very regular layers, which are interstratified with thin partings of shale. A copious spring issues from it, and the band can be traced for one hundred and twenty paces to the westward of the spring, with a general dip of N. 30° W. $< 75^{\circ}$; while it is again met with in a bearing of N. 80° E., at a distance of about 250 paces from the same spot.

McDonald's
limestone.

Millstone Grit
rocks.

The rocks in the valley to the southward, judged of by two exposures on the north and one on the south side of McLean's Brook, are red shales, red sandstones, and red conglomerates, associated with greenish-drab sandstones and shales. Strata of a similar description are occasionally exposed in the valley all the way to Sutherland's River, and the whole bear a strong resemblance to the deposits of the Millstone Grit.

Strike of lime-
stones.

The strike of the limestone, near McDonald's house, points towards the exposures near his saw-mill, and notwithstanding the irregularities which the latter display, the whole may belong to one and the same band. Supposing this to be the case, it is very evident that the trend of the strata associated with the limestones diverges considerably from that of the measures accompanying the Widow McLean and the McBean coal seams. At right angles to the McBean seam, there is between it and McDonald's house, a distance of three-quarters of a mile, and in this there has yet been discovered no evidence of the emergence of the great mass of black shales, which it has been previously stated abuts against the Mill-road fault, notwithstanding that the Lawson fault is a considerable upthrow to the south in the interval. It cannot be supposed that the Mill-road fault suddenly annihilates these black shales, and this disturbance being a downthrow to the eastward, the inference is that the shales underlie the arenaceous coal measures to the east of it; and as the strata associated with McDonald's limestones probably belong to the Millstone Grit series, it follows that they must be brought to the surface by some very great fault running at an uncertain distance north of McDonald's house. The course of this fault has yet to be ascertained; but one point on it probably occurs at the exposure of red conglomerate above McDonald's mill-pond.

Absence of
black shales at
the surface.

Probable fault.

It will be seen by the sequel that the thickness of the black shales can scarcely be much less than about 2000 feet. According to Mr. Hartley, the workable coal seams which have been tested on the west side of

the East River, are interstratified in an additional thickness of measures, equal to about 500 feet, and below these he states the occurrence of a series of arenaceous and argillaceous beds, without any very valuable coal seams, but still belonging to the productive measures, of which the volume may be 1000 feet more. It thus appears possible that without allowing anything for the New Glasgow conglomerates the great break which brings the Millstone Grit rocks to the surface at the east end of the coal field, may be an upthrow of at least 3500 feet; it will probably run across from the South to the North fault and it may appropriately be termed the great East fault.

Great break

East fault.

The relation of the Widow McLean seams to the McBean eight-feet seam not having been as yet ascertained with accuracy, it is a question how far they may be beneath the bottom of the Marsh pit in the Middle synclinal. But as their outcrop has not presented itself on McLellan's Brook, it seems probable that they are sufficiently deep seated to abut, in their south rise, against the black shales in the Mill-road fault. The Widow McLean seams can therefore scarcely be expected to come to the surface in any other place than south-east of the McBean eight-feet seam; but it would appear from a comparison of Sections 2 and 3 with Sections 6 and 7, that Messrs. Mitchell and Barton have as yet scarcely carried their researches far enough behind that coal seam to reach them.

Horizon of the Widow Mc-Lean seams.

It has been conjectured that the Widow McLean seams may be the eastern out-crop, in a deteriorated condition, of some of those workable seams which underlie the great mass of black shales. If such were the case, it would follow that the fault between them and the Mountain seam would be a much greater break than has been supposed by me, and the block of strata with which these seams are associated would apparently be a quadrangular mass limited by four great breaks, namely, the one just alluded to, the Lawson fault, the great East fault and the South fault. But until the search for the McBean seam behind the Mountain seam, and for the Widow McLean seams behind the McBean seam, has been exhaustive, it will be premature to speak with anything but doubt of the structure of this part of the coalfield.

On the St. Lawrence area, black shales appear to have been obtained in nearly a dozen trial-pits, embraced in a space of about one hundred acres, lying southward of Haliburton's main shaft. The shales are characterised by the presence of an abundance of *Cythere*, with many small scales and minute bones of fishes, but it does not appear probable that the shales will have any very great thickness. Their position seems to be on a continuation of the axis of the Middle synclinal, and the measures may be expected to preserve on the whole a moderate inclination. Indeed Mr. J. Weir, formerly employed as pitman by Mr. Haliburton, pointed out to me a trial-

St. Lawrence area.

Black shales.

Middle synclinal.

GEOLOGICAL SURVEY OF CANADA.

one hundred and eighty paces from the main shaft in a bearing , where he informed me the measures were quite flat. It is true Brain, formerly Mr. Haliburton's overman, states in his manual, with a copy of which Mr. Haliburton was so kind as to , that the measures in this same pit dip S. 20° E. (Mag.) < 30° ; t about seventy paces southward he registers the dip as N. 20° < 30°. In the interval the measures will naturally become flat, re is no great discrepancy in the structure as given by the two. . Lawrence main shaft is eighty feet deep, and according to 's register the coal was penetrated at a depth of forty-five feet. ore but three feet nine inches thick, but ten feet above the the shaft it had thickened to eight feet horizontally, while at et further down on the slope of the seam it became eleven feet, eing good coal and the other coaly shale. At the depth of the lery or level was cut in the coal twenty-two feet to the westward en feet to the eastward. A transverse drift was carried back haft at a depth of seventy-five feet, and a bore-hole then driven ngles to the slope of the measures, which dipped towards the ngle of 75° ; in these, according to Mr. Weir, there were inter- following strata :

In the drift and shaft.		
	<i>Ft. In.</i>	<i>Ft. In.</i>
ireclay	9 0	
ls	7 6	
reclay.....	12 0	
	<hr/>	28 6
In the Bore-hole.		
ard fireclay....	12 0	
oft fireclay.....	1 6	
ale.....	7 6	
ard freestone.....	31 0	52 0
	<hr/>	<hr/>
		80 6

etails are given because they seem to indicate, by the tilted the measures and the colours of the strata, which are character- Millstone Grit series, that the face of the great North fault or mediate branch of it, must, at the depth of eighty feet from the , close behind the bottom of the shaft.

iously stated, the out-crop of the McBean eight-feet seam on south-eastern boundary of the McBean area, and entering upon ' ll and Barton area, gradually bends round and assuming more than shewn in its previous course, is supposed to be interrupted

The precise course of this disturbance has not yet been ascer- is it definitely know whether it is an upthrow or a downthrow.

If it were the latter, its effect would naturally be to steepen the dip of the coal seam where in contact with it, and this dip, whatever its rate, would probably be northward. We see in the St. Lawrence pit that the effect of the North fault has been to produce a slope of the measures in an opposite direction, and it does not appear to me an improbable conjecture that the coal seam penetrated in that pit may possibly be the return of the eight-foot seam to the surface on the north side of a trough which lies between the two dislocations. It is possible also that the seam may abut against both these faults, and perhaps against the supposed great East fault, and thus shew no out-crop around the east end of the area which it may occupy, until it emerges near the St. Lawrence pit. After emerging, the out-crop gradually separates a little from the North fault in the neighbourhood of that pit; but as the fault gradually gains upon higher measures as it proceeds westward, the out-crop of the coal seam will again probably approach the fault and once more become concealed by it.

Possible equivalence of the St. Lawrence seam.

If the fault which interrupts the McBean eight-foot seam were an upthrow, the coal bed in the St. Lawrence pit could scarcely represent it, and further facts would have to be ascertained before the true structure could be given. It may be remarked, however, that the eastward strike of McBean's six-foot seam on the upper part of Marsh Brook, which is conjectured to be equivalent to the George McKay seam, appears to run such a course, that it will probably come against a mass of conglomerate which occurs south-eastward from Mr. William Grant's house in that neighbourhood. This conglomerate is supposed to be the same as that which underlies the coal seam in question, as stated in Section 6. The dip of the measures is there northwestward, and the presence of the conglomerate in such a relation would, in reality, indicate an upthrow on the east side of a disturbance. If the course which this disturbance may present, should point to the eastward interruption of the McBean eight-foot seam, the upthrow of this seam might be considered as established.

Upthrow fault.

About twelve chains from the north-east corner of the McBean area in a bearing N. 55° E. there is an exposure of greenish-gray conglomerate, dipping N. 43° W. $< 40^{\circ}$. Were the fault an upthrow, this exposure would seem to represent the lower conglomerate of Section 6, and the crop of the McBean eight-foot seam would probably have the same relation to it on the east side of the disturbance, that McBean's slope has to the conglomerate on the west.

Conglomerate.

The Mill-road fault, as has been stated, runs about S.S. E. from Black's mill-site on McLellan's Brook, and its course can be pretty well seen in the line of demarcation which it presents between the arenaceous measures on the east and the black shales on the west. But what its precise course may be, northward, or what effect it may produce upon the distribu-

Mill-road fault.

Arenaceous
measures.

tion of the measures in that direction, I have found no satisfactory evidence to determine. Arenaceous measures extend westward beyond the direct northern prolongation of the bearing given to the fault; but with a very little deflection westward the chief mass of sandstones would still keep on the east side, where they rise into a considerable hill, along the south-western foot of which the St. Mary's road runs to New Glasgow. The eastward prolongation of this hill appears to constitute the north-west limit of the Middle synclinal. The hill is supposed to have an anticlinal form, and rising on it to the north-eastward from Black's mill-site, we have some evidence of north-western dips on the land of Mr. Andrew Campbell. Near his house on the top of the hill is a well sunk through three feet of soil and thirteen feet of arenaceous shale and shaly sandstone; the dip, as explained to me by Mr. Campbell, was found to be N. 17° E. < 10°.

Anticlinal form.

N. W. dips.

North synclinal.

Farther north-eastward the rocks are so covered with drift that I have not been so fortunate as to meet with exposures shewing slopes in the same direction, but evidences of a synclinal, whose axis would run on the other side of the hill until cut off obliquely by the great North fault, are met with under three-quarters of a mile north-eastward, where several coal beds have been worked to a small extent on Potter's Brook. The ground, however, is here so broken by faults running in various directions, while the amounts of displacement are not known, and so affected by minor undulations, that it is next to impossible to correlate the seams with one another with any degree of certainty.

A. McKay's
five-foot seam.

One of these seams occurs on the south side of the brook, where it was formerly worked by Mr. Alex. McKay, who informed me that the coal was of excellent quality, and who gave me the following section of the ground immediately beneath :

		Ft. In.
	Coal—A seam of excellent quality.....	5 0
Calcareous underlay.	Ash-gray calcareous underlay, characterized by a great abundance of well-preserved forms of <i>Stigmaria</i> ,.....	1 6
	Ash-gray fireclay, becoming mottled with red by exposure to the weather, and holding <i>Stigmaria</i> ,.....	7 0
	Coal—A seam of which the thickness was not ascertained.....	0 6
		14 0

The strike of the out-crop, as determined by the work on it, is about N. 62° W., with a slope to the north-eastward, but I am uncertain of the angle of inclination.

Fraser's five-
foot seam.

About 300 paces N. 20° E. from this, on the north side of the brook, a horizontal gallery was opened many years ago (the colliery was visited by me when it was in work in 1841) by the late Mr. Alex. Fraser, in a seam of excellent coal from four and a-half to five feet thick. The mouth of the

gallery is about fifteen feet over the brook and immediately under the south side of the telegraph road. The gallery in its general course is about N. 82° W., and it extends about 120 paces under ground, with a sudden turn southward about thirty paces in. The dip is northward, but as the natural out-crop on the face of the bank presents an arch, first rising southward towards the road and then falling again beyond to the level of the brook farther down, it is evident that the horizontal gallery would turn at some uncertain distance beyond the extent to which it has been carried, and come out again to the crop in the bank at the same height of fifteen feet above the brook, shewing by this a fold over the axis of an anticlinal form or roll in the strata. On the south side of the brook, nearly opposite to this point, a slope sinks southward in what is supposed to be the same seam, and a rise in this on the south side of a synclinal might be expected to bring the seam into junction with that worked by Mr. Alex. McKay; but a fault appears to run between the two positions on or near the axis of the synclinal and renders the identification less certain. According to Mr. Poole, however, a calcareous underclay of twenty-two inches supports the Fraser coal, * and further assimilates the two seams.

Small anticlinal form.

Fault.

Calcareous underclay

Immediately east of the mouth of Fraser's gallery a fault occurs, and vertical strata met with by Mr. George McKay, in a pit sunk about 135 paces southward, shew the bearing of the fault to be about S. 16° E. About 140 paces eastward of this fault, and on the south side of Potter's Brook, Mr. Lawson has sunk a slope for the Pictou Mining Company in a coal seam of which the following is a section:—

Fraser's fault

Lawson's coal seam.

	<i>Ft. In.</i>
Cannel coal, varying in thickness from three to nine inches.....	0' 6
Mineral charcoal mixed with coal.....	0 2
Good bituminous coal, of which from four to six inches at the bottom appears to be of a friable character.....	3 0
	<hr/> 3 8

The bearing of the slope is S. 26° E., with an inclination of 20° for twenty feet; of 35° for eighty feet; of 20° for thirty-five feet, with a sudden diminution to 16° at the bottom, where a disturbance occurs running N. 52° W. This disturbance cannot, however, be a great one, as it produces little displacement at the out-crop of the seam; but at some distance farther to the deep of the seam (supposed to be about seventy paces from the mouth of the slope) a much more important dislocation probably occurs. Its position is inferred from the presence of about thirty feet of vertical sandstone about nine chains to the eastward of the slope, and a coal seam two and a-half feet thick, in a vertical attitude, about fifteen chains beyond; the

Small fault.

A larger fault.

* Transactions of the Nova Scotian Institute of Natural Science for 1863, p. 32.

nates near the establishment of the Crown Coal, Brick and Pottery Company. The higher part of the ridge is composed of a brownish-drab sandstone of considerable thickness. This probably underlies the East River eight-foot seam, but at what vertical distance is uncertain.

Sandstone
ridge.

At the Pottery works a pit was sunk to a three-foot seam of remarkably good coal by Mr. Jos. Richardson, and is hence called the Richardson seam, the measures intersected in the pit being as follows, with a dip of S. 57° E., < 19½°.

The Richardson
three-foot seam.

	Ft.	In.
Drift.....	16	0
Grey argillaceous sandstone, gradually crumbling in the weather.....	24	0
Coal— <i>The Richardson seam</i> , of remarkable good quality.....	3	0
Grayish-drab fireclay, with abundance of <i>Stigmaria</i>	3	0
Light yellowish-drab fireclay.....	11	0
	<hr/>	57 0

These measures would underlie the mass of sandstone forming the ridge, and the out-crop of the coal seam would follow the foot of the rising ground up to the great North fault; where it crosses the road to the Scotch church there is a red ferruginous spring to mark its probable position; but in its south-westward course, the seam will probably be interrupted by a dislocation of which there is evidence at no great distance beyond the Pottery. The excellent quality of this coal gives it a resemblance to that of a bed two and a-half feet thick, which, as will be seen by Section 7, is about eighty feet beneath McBean's eight-foot seam.

Comparison of
seams.

At Chisholm's mill-pond, on Potter's Brook, about thirty chains southward of the Pottery pit, an excellent seam of coal, said to be well suited for blacksmiths' purposes, and reported to have a thickness of three feet, was formerly worked by the Rev. Mr. Stewart, and is hence called the Stewart seam. The measures associated with it, as near as I could ascertain, are as follows, in descending order:

	Ft.	In.	Ft.	In.	
Black carbonaceous shale.....			10	0	
Coal— <i>The Stewart seam</i>			3	0	Stewart's seam.
Gray underclay.....	3	0			
Measures concealed, but probably black carbonaceous or argil- laceous shale	120	0			
Gray sandstone, weathering drab	5	0			
	<hr/>		128	0	
Coal and black argillaceous shale.....			0	1	Small coal seam.
Gray soft fireclay.....	1	6			
Gray hard fireclay with indications of <i>Stigmaria</i>	3	6			
Grayish-drab sandstone.....	2	0			
Gray argillo-arenaceous shale.....	1	0			
Grayish-drab sandstone.....	4	0			

		<i>Ft. In.</i>	<i>Ft. In.</i>
	Gray arenaceous shale.....	0 6	
	Blackish argillaceous shale.....	0 6	
	Gray flaggy sandstone.....	36 0	
	Black carbonaceous and argillaceous shale, only partially seen..	50 0	
		<hr/>	
	<i>Coal.—Cannel</i>		99 0
			0 11
Small coal seam.	Gray fireclay.....	3 0	
	Black carbonaceous shale, only partially seen.....	105 0	
	Grayish-drab sandstone.....	25 0	
		<hr/>	
			133 0
			<hr/>
			374 0

Black shales.

The sandstone at the base of the preceding section is seen on the west side of the New Glasgow road, at the bridge over Potter's Brook; and proceeding down the brook from this, the cliff on the right bank gives a continuous descending section, in which nothing is met with but black shales. These have been carefully examined by Mr. Hartley, and the direct breadth of them in the bearing N. 80° W. which is at right angles to the strike, is computed to be very nearly 475 paces, with angles of inclination varying from 33° to 47°. This would give a thickness of about 700 feet, and if to this be added 500 feet for what may be concealed to the middle of the river, the distance being fifteen chains and the supposed inclination 30°, the thickness would not be less than 1200 feet.

Chisholm's mill-pond.

The strike of the Stewart coal seam across Chisholm's mill-pond and in the two or three crop-pits on the north side of it, is about N. 18° W., with an inclination to the eastward of about 30°; but a search for the seam in this direction, by trial-pits approaching the Pottery, has proved unsuccessful. In a cliff on the right bank of the East River, above the railway bridge, there is a considerable exposure of strata, which very probably underlie the seam at a considerable depth. About a quarter of a mile above the bridge, black shales, which are a part of the strata exposed, dip N. 40° E. < 23°—25°, and this dip is preserved on the strike for 300 paces; but approaching within 200 paces of the lower end of the bridge, the strata suddenly becoming arenaceous, plunge with a dip of N. 5° W. < 43°—45°, maintained for 150 paces measured directly across the strike, while close by the extremity of the bridge there appears to be a dislocation. This displacement, which may be called the Bridge fault, would seem to run a little south of the Pottery pit on the Richardson seam, and the sudden bend in the measures would carry the Stewart seam considerably out of its course to the westward, and thus, aided by the break, which is probably a downthrow on the north side, would bring it much nearer the river.

Arenaceous strata.

Bridge fault.

Southward from Chisholm's pond the measures appear gradually to assume a more westerly bearing, the strike becoming S. 20° W., and at

the distance of between 300 and 400 paces from the pond they are interrupted by another dislocation. The evidences of this were observed by Mr. Hartley on the right and left banks of Potter's Brook, about a quarter of a mile below the New Glasgow road, where the dip of the black shales becomes S. 5° E. < 60°. The course of this fault seems to be about west ; it is a downthrow on the south side, supposed to be of about 200 feet, and on this side of it the black shales turn south-eastward and gradually conform with the arrangement which they present on McLellan's Brook.

The great mass of black shales which immediately succeeds the band of sandstone on the west side of the New Glasgow road at Potter's Brook seems to indicate that we have here the base of the arenaceous measures and the summit of the black shales, and the position and arrangement of the mass render it probable that it is to be considered an addition to the thickness which Mr. Hartley has found to exist at the highest horizon in them on the west side of the East River, less the 200 feet repeated in the Potter's-brook fault. Their volume over the Main coal seam (more particularly described in Mr. Hartley's Report,) is, according to him, 1128 feet. If to this we add the 1000 feet occurring on and near Potter's Brook, we have a thickness of 2128 feet.

Summit of
black shales.

Thickness of
black shales.

It has already been stated that McLellan's Brook, below Black's mill-site, presents a great body of these black shales, and on the East River, above the mouth of this brook, there are farther exposures, reaching to the out-crop of the Main seam, where a slope has been opened on it by the Pictou Mining Company. The whole will give to the series a transverse breadth of a little more than a mile and a quarter, with a north-eastward dip varying in inclination from 8° to 24°. Such a computation as can be made from these elements would assign to the black shales on the west side of the Mill-road fault, at Black's mill-site, a volume of 1740 feet. As this is 388 feet less than the total thickness stated above, it would follow that the displacement produced by the Mill-road fault would equal this, with as much in addition as the base of the arenaceous measures may be underneath the surface on the east side of the fault at that spot. As already stated, the precise course of this fault northward from Black's mill-site remains a matter of uncertainty ; and whether it is deflected so far as to run for the black shales at Potter's Brook and come to the East River near the railway bridge must continue a subject for future investigation.

Break in Mill-
road fault.

Bearing of Mill-
road fault.

The out-crop of the Main seam, upon which the coal works of the General Mining Association are situated on the west side of the East River, crosses the New Glasgow road about a quarter of a mile above the turn to the Albion mines, and the slope of the Pictou Mining Company, which for the present is abandoned, is seen about 120 paces east of the road. As a detailed description of this seam, as observed by Mr. Hartley on the

Main seam.

Reference to
Mr. Hartley's
Report.

Strike of Main seam.

west side of the river, was necessarily to be a part of his Report, it was left to him to follow the investigation of it and the seams and ground associated with it to the eastward. I shall therefore refer to him for what is to be said of it and of a shaft sunk to it on Grant's farm, further to the eastward. The strike of the seam from the Albion mines to the slope is about S. 70° E. (or S. 47° E. Mag.), the dip at the mouth of the slope being N. 20° E. (or N. 43° E. Mag.) $< 19\frac{1}{2}^{\circ}$; but here the out-crop turns a little more southward, and a trial-pit has been sunk on it a quarter of a mile farther, in the bearing S. 45° E., thirteen chains beyond which it will come upon a fault, the course of which, as ascertained by Mr. Hartley on the west side of the river, is almost exactly east. About thirteen chains on the course of this fault a coal seam occurs on the south side of it, on the land of Mr. Donald McLeod. The following is a section of the seam, as given to me by Mr. Lawther, who sunk the trial-pit:—

McLeod seam.

	<i>Ft. In.</i>
Coarse coal.....	2 6
Coaly shale in very thin layers.....	3 0
Good coal, or the best part of the seam.....	2 6
	<hr/>
	8 0

The crop has been traced a distance of about 190 paces, and the dip of the strata is about N. 76° E. $< 19^{\circ}$, black shale being above the coal seam, and sandstone supporting the underclay beneath. If this were the Main seam the displacement of the fault would be an upthrow of 286 feet on the south side; but the character of the seam is more like some of those lower down, and the upthrow, therefore, is probably much greater.

South fault.

This is the only coal seam I could hear of that has been struck on the south side of the fault above mentioned. Between the trial-pit on the coal, however, and the great South upthrow, which appears to pass a little south of the house of Mr. Neil McKay, there is a space of a mile in breadth. The strata striking south would run across this nearly at right angles to the direction of the South fault. If the coal seams reach so far it is probable that they may be deflected somewhat to the west on approaching the upthrow; but as already stated, it is not impossible that a southern portion of the space may be occupied by rocks of the Millstone Grit series, brought into place by a fault subordinate to the great one. I have no facts, however, on the east side of the East River, to shew how much this may be.

Black shales.

About 200 paces less than a mile from the run of the coal seam on Donald McLeod's land, and at right angles to the strike, a pit has been sunk for water on the land of Mr. William McLeod. The pit is sixty-three feet deep; no water was obtained, and judging by the *débris* lying about the mouth of the pit, it penetrates nothing but black shale. A lump of asphaltum is said to have been obtained at the depth of twenty-five feet,

but I presume it may have been oil shale, or highly carbonaceous shale. The position of the excavation is on the road which crosses McGregor's Mountain, and it is about 800 paces north of the South fault.

About 1400 paces still farther east, but, as is supposed, on the east side of the Mill-road fault, there is an old gallery or level on a seam of coal said to be three feet thick, over which rises a considerable thickness of black shale. The mouth of the level is seen at a great bend of McLellan's Brook, about 240 paces above the Fulling-mill bridge, and a little over 800 paces north of the South fault. The dip of the strata appears to N. 54° E. < 18°.

Three-foot coal
seam, above
Fulling-mill.

About 300 paces farther up the bend of McLellan's Brook, but not more than 300 paces on the road which runs southward from the Fulling-mill bridge, there is an exposure on the right bank of the brook, which would be on the east side of the Mill-road fault, and on the south side of the Fulling-mill fault, but it is uncertain to what division it may belong. The base of it reaches to within fifty paces of the Devonian rocks brought up by the great South fault. The following is a section of the strata in descending order:—

Section of mea-
sures near De-
vonian rocks.

Fl. In.

Greenish-drab arenaceous shale interstratified with layers of greenish-gray sandstone	22	0	
Black argillaceous shale with thin layers of sandstone.....	2	6	
Greenish-drab sandstone	0	6	
Black argillaceous shale.....	15	0	
Gray shaly sandstone	5	0	
Greenish-gray conglomerate with siliceous pebbles of various sizes up to an inch in diameter, in an arenaceous matrix..	1	6	Conglomerates
Black shale.....	1	0	
Greenish-gray conglomerate as before, with some sandstone	6	0	
Dark gray shaly sandstone	10	0	
Greenish-gray conglomerate as before.....	2	0	
Greenish-drab sandstone	1	0	
Black shale.....	3	0	
Greenish-drab sandstone	0	6	
Black flaky argillaceous shale weathering to a light gray clay....	0	6	
Greenish-gray sandstone with indications of <i>Stigmara</i>	0	6	
Greenish-gray conglomerate, as before	0	3	
Grayish-drab sandstone.....	3	0	
Coal	0	0½	Small coal seam
Greenish-drab sandstone with uncertain indications of <i>Stigmara</i> , with greenish-gray conglomerate at the bottom.....	2	6	
Black argillaceous shale with much iron pyrites.....	2	6	
Greenish sandstone, mottled with red, probably from weathering,	15	0	
Reddish sandstone, in some parts approaching to a drab; the reddish colour is perhaps due to weathering.....	20	0	Red sandstone.
	114	3½	

BOLOGICAL SURVEY OF CANADA.

Character of some of the strata of this section induce the mass may belong to a lower horizon than the on the south side of the Fulling-mill fault, though still Productive measures; and it may have been brought h it occupies by some entanglement with the South

f a certainty to belong to a lower subdivision of the than the Productive measures have been as yet outh fault, between these and the Devonian series, that some red rocks which Mr. Hartley has noticed on East River may possibly be such. It is to be remarked, ed rocks appear to have the same eastward dip as the e measures above them, in so far as the McLeod coal s guide; and they may represent a deeper portion asures than seen elsewhere in this coal field, with New Glasgow conglomerate.

he typical character of this conglomerate appear to the surface by either the South or the East fault, West fault. This does not, however, disprove their sneath the whole of the Productive area abutting and constituting the base of Dr. Dawson's Middle ferred by Mr. Hartley.

ms to be supported by the presence, immediately on nglomerate, of the coal seam worked by Mr. William the burning of his limestone, and another said to ough the occurrence of these is not strengthened by the any of the larger workable coal seams in the Pictou ts of which have yet to be examined by the officers of . not be surprising to find, in a country apparently so ocations, that the absence of the larger seams may be resulting from some of these faults, of as important a affecting the productive part of the field above New

ess of the Carboniferous rocks of Nova Scotia, as f at the Joggins in 1843 is about 14,700 feet. The o far as our examinations have gone on the present ding order as follows:

	<i>Fl.</i>	<i>Fl.</i>
1, according to Mr. Hartley's Section 1, without for the East River series of Section 2, which ition wholly or in part.....		3773
glomerate, as measured on the east side of the		1600

Productive coal measures:

Ft. Ft.

Measures on the west side of the East River, according to

Mr. Hartley's Section 4..... 2453

Measures on the east side of the East River:

Ft. Ft.

Black shales above Mr. Hartley's Section 4.... 1000

Arenaceous measures of this Report.

Section 3, Division C..... 924

Section 2, Division B..... 819

Section 1, Division A..... 223

Strata above A 148

2114

3114

5567

10840

When it is considered that in the sections above given on both sides of the East River we do not in any case, with the exception of the New Glasgow conglomerate, suppose that we have attained either the bottom or the top of the series to which it belongs, and that the subdivisions at the summit and at the base of the whole Carboniferous group are wanting, though deposits belonging to them are not far removed from the district examined, it seems probable that the volume assigned to the Carboniferous rocks at the Joggins will be fully maintained in the Pictou region.

I have the honour to be,

Sir,

Your most obedient servant,

W. E. LOGAN.

REPORT

OF

MR. EDWARD HARTLEY, F.G.S.,

ADDRESSED TO

SIR WILLIAM E. LOGAN, F.R.S., F.G.S.,

DIRECTOR OF THE GEOLOGICAL SURVEY.

MONTREAL, 30th November, 1869.

SIR,—In accordance with your instructions of July, 1868, I devoted the remainder of the season of that year to the exploration of that portion of the coal field of Pictou, Province of Nova Scotia, which lies to the west of the East River, and now have the honour to present to you the following Report. Having been made aware that my investigations were to be more especially devoted to the productive portion of the measures, no detailed examination of the older and outlying rocks has been made, except in so far as seemed necessary for the proper definition of the limits of the productive coal area. My description of such rocks will, therefore, be somewhat incomplete. The presence of numerous faults or dislocations of strata, throughout this region, combined with the fact that it is covered with an unusual quantity of drift, renders accuracy in the preparation of sections and in the mapping of the outcrops of coal seams, a difficult task, and in many places the facts which it has been possible to obtain, will only enable me to show the general structure.

In the preparation of this Report, and of materials for a map, I have been greatly assisted by the records of various mining companies and of individuals owning or working the coal areas of this section, also by private and public railway surveys, land surveys, and in the case of working collieries, by such underground plans as I have been able to procure.

I would here acknowledge the many courtesies received by me from those whom I have met in the course of my examinations. In all cases the fullest information has been granted, for which my sincere thanks

Acknowledgments for assistance.

GEOLOGICAL SURVEY OF CANADA.

e and I would especially acknowledge my obligations to the gentlemen, for the information they have so freely given me : H. Crosskill, Assistant Provincial Secretary ; Mr. Avard Longley, Commissioner of Railways of the Province ; Mr. J. Rutherford, Provincial Inspector of Mines ; Mr. W. A. Hendry, Deputy Commissioner of Crown Lands ; Mr. James Hudson, M.E., Chief Manager of Mining Association of London ; Mr. Jesse Hoyt, General Agent of Acadia Coal Company of New York, U. S. ; Mr. James Dunn, Agent of the Intercolonial Company of Montreal ; Mr. Truman, Agent of the Nova Scotia Coal Company ; Mr. J. P. Lawson, Engineer, New Glasgow ; Mr. J. B. Moore, Contractor for the Intercolonial Coal Company's railway ; Messrs. Hanning, Civil Engineers, in charge of the construction of the same railway ; Mr. William Barnes, Engineer of Halifax ; Mr. R. G. Haliburton, Col. R. B. Sinclair, R. Kirby, of Halifax ; Mr. Daniels, of Pictou Mining Company ; B. Leather, C. E., of New Glasgow ; Mr. A. P. Ross, of Pictou ; J. Weir, of Pine-tree Brook.

Special attention is called to the kindness of Messrs. Hudson, and Dunn. At the Albion mines I have not only had Mr. Hudson's permission to examine and copy many valuable records and drawings, but he has presented the Survey with complete copies of his extensive underground plans, copies of drawings and specifications of machinery, and of the surveys made for the General Mining Association. By his permission, most satisfactory information was given me in my examination of the machinery by Mr. Thomas Blenkinsop, engineer, and of the underground work by Mr. William Hall, interviewer, and both of these gentlemen I would especially compliment on their admirable management of the works under their charge. I would also remark that to the skill of Mr. Thomas Rutledge, of the same company, we are indebted for the complete set of drawings presented by Mr. Hudson.

At the Acadia collieries also, I have been allowed by Mr. Hoyt full access to the company's records and plans, and am indebted to him for the permission, and for much verbal information useful in my survey. Information concerning machinery and underground work, has been freely furnished by Mr. William Blacker, general overman, as also much information of a general character. I would also acknowledge courtesies of a general character received from Mr. J. W. Clendenning of New York, General Agent of the Acadia Coal Company, who was kind enough to allow me to work in the company's building. In the examination of the Intercolonial Company's works and area, I have been materially aided by the permission of Mr. Dunn, who furnished plans, records and information. In the instruction, Mr. James Wilkes, interviewer, and Mr. Joseph

Richardson, underground overman, have also given me full information concerning machinery and underground work. I have also been assisted by plans of the railways by Mr. Moore, and a record of pits and borings by Mr. Barnes.

The area examined is included between the East and Middle Rivers of Pictou, and extends laterally from the Conglomerate ridge, a prolongation of Fraser's Mountain on the north of New Glasgow, to the Fox-brook road between Coal Mines and Hopewell villages. The rocks observed may be included under the following heads:

1. Pre-Carboniferous.
2. Millstone Grit.
3. New Glasgow conglomerate.
4. Productive coal measures.

Rocks observed

These rocks I now propose to describe, and will then treat of their distribution in this region.

1. PRE-CARBONIFEROUS.

Pre-carboniferous.

Between the East and Middle Rivers, on the northern ridge, there appears a series of metamorphic rocks, unconformable to the overlying Carboniferous, consisting of quartzites, felsites, altered slates, and conglomerates, in which I could find no distinguishing fossils. This series has however been observed by Dr. J. W. Dawson, and in his *Acadian Geology* he states that they are "probably of Devonian age." *

Dr. J. W. Dawson.

Some of these masses are quartzites, extremely tough and compact, of colours varying from dark sap-green to blackish-green, and weathering to a rust-brown. Others are quartzites of similar colours, weather opaque yellowish-white, and appear quite free from iron; while others still are of a dark olive-green, and weather to a very dark blackish-brown.

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Felsites varying from pistachio-green to olive-green, and weathering deeply to a rust-brown, are also found. These appear to be brecciated wherever met with, and although compact are always much shattered.

Felsites.

A large portion of the rocks consist of altered slates, ranging in colour from dark olive-green to dull greenish-grey, and weathering from an opaque white to a rust-brown. It is difficult, in many cases, to distinguish between the slates and quartzites; in fact they seem to pass into each other by imperceptible gradations.

Altered slates.

Two descriptions of conglomerate, and possibly a third, are associated with the series. The first is one in which both cement and pebbles are of a greenish-gray colour, and so nearly alike in hardness that in breaking a mass the pebbles and matrix are fractured evenly across. This rock is

Conglomerates.

* *Acadian Geology*, p. 319 of second edition.

extremely hard and tough, and appears to pass into quartzite by a gradual diminution of the pebbles, which are themselves quartzite of a slightly lighter tinge than that of the silicious cement. The second conglomerate is seen but in one locality, on McCulloch's Brook, where it forms a bed of some twenty feet in thickness, but it is so much injured by weathering that scarcely more can be said of it than that some of the pebbles are of a vermillion red jasper, with a cement weathering to a bright brick-red.

But one band of limestone of this series has come under my observation. This is seen at Waters's limestone quarry, at the end of the Smoky-town road, where it appears to be about twenty feet in thickness, included within quartzites and altered slates. This limestone is of excellent quality, and is of a white or bluish-white color, with a tinge of ochre-yellow in the cracks; it weathers to a dead white with a porcellaneous lustre, the edges of weathered specimens showing some thin laminæ in relief, giving a surface resembling that of an oyster-shell.

These rocks form a ridge on the north of that portion of the coal field which has been examined, and going west are first met with about a mile from New Glasgow bridge, on a considerable rise of ground known as Waters's Hill, and thence scattered exposures and the general character of the ground indicate their presence on this hill as far west as the Inter-colonial Company's railway: Waters's limestone quarry is on the summit of this hill, and besides the limestone the green felsites are well exposed. The dip appears to be S. 17° W.* $<40^{\circ}$ but the measures are disturbed by a fault. In the railway cutting at the west end of the hill good exposures are met with of the quartzites and greenish conglomerate, with a general westerly dip at high angles, but the true stratification is rendered very obscure by numerous dislocations and irregular cleavages throughout the whole mass. From the railway bridge over Waters's Brook the altered slates and conglomerates are well exposed in the cliffs forming the banks of McCulloch's Brook all the way down to its junction with the Middle River. Here, with a direct breadth of about one-third of a mile northward from the junction, and bounded on each side by faults separating them from the newer strata, the rocks of this series cross the Middle River, on the left bank of which they form a low ridge, and on the mill-pond of the axe factory in that neighborhood occur the most western exposures that have been examined.

2. MILLSTONE GRIT.

From widely extended examinations of the Carboniferous rocks of this Province, Dr. J. W. Dawson, in his *Acadian Geology*, has subdivided

* The bearings in this Report are astronomical, the variation for magnetic north being $23^{\circ} 15'$ W. See note p. 6.

this system in Nova Scotia, into five "subordinate groups or formations," as follows, in descending order:*

"1. *The Upper Coal formation*, containing coal-formation plants but not productive coals.

Dr. Dawson's
classification of
Carboniferous
rocks.

"2. *The Middle Coal formation*, or coal formation proper, containing the productive coal-beds,

"3. *The Millstone-grit Series*, represented in Nova Scotia by red and gray sandstones, shales and conglomerates, with a few fossil plants and thin coal seams, not productive.

"4. *The Carboniferous Limestone*, with the associated sandstones, marls, gypsums, etc., and holding marine fossils recognised by all palaeontologists who have examined them as Carboniferous.

"5. *The Lower Coal measures*, holding some, but not all, of the fossils of the Middle Coal formation, and thin coals, not productive, but differing both in flora and fauna from the Upper Devonian, which they overlie unconformably."

Provisionally adopting the above nomenclature, it would appear that the Carboniferous rocks which I have here met with, are all referable to the Middle Coal formation and the Millstone Grit. Subdivisions 1, 4, and 5, are wanting throughout the region examined, and in some places the unconformable Devonian rocks appear to encroach on the base of the Middle Coal formation without the presence even of the Millstone Grit.

Subdivisions
wanting.

The Millstone Grit is here represented by a considerable mass of red, green and gray sandstones and arenaceous shales with mottled sandstones, of limestones more or less pure, and of coarse and fine conglomerates, the whole manifestly underlying the Middle or Productive coal formation. This will be best described by two sections of strata belonging to the series, which, as now given, are to be considered as representing the larger rock masses rather than the detailed strata of this subdivision; but as the Productive coal measures, where their limits are accurately known, always seem to be separated from this series by faults, while in some places at least, the subdivisions are unconformable with one another, it would not only be impossible to give a section graduating upward into the Productive measures, but it would also be imprudent to hazard an opinion as to the exact horizon which the sections occupy in the Millstone Grit.

Red, green and
gray sandstones
limestones and
conglomerates

Faults.

The first of these sections occurs on McLeod's Brook, lying to the west of the coal field, and affords a fair representation of a considerable portion of these rocks; but as the exposures, though frequent, are not continuous, it is to be regarded only as an approximation. The strata are given in descending order.

* Acad. Geol., second edit. p. 129 et seq.

SECTION 1.

Measures on
McLeod's
Brook.

MEASURES ON McLEOD'S BROOK FROM GAILLOCH ROAD TO MIDDLE RIVER ROAD.

	<i>Feet.</i>
1. Reddish-grey, brick-red, and mottled sandstones in alternations; some bands of about an inch in thickness are a green conglomerate with quartzite pebbles.....	450
2. Red sandstones.....	210
3. Greenish-drab sandstones, weathering red; some bands are red throughout.	325
4. Reddish-brown sandstones.....	380
5. Mottled Indian-red and light yellow sandstones tinged with brown; the predominating colour is Indian-red, the yellow portions being usually only from a quarter to a half inch in diameter, and sometimes assuming a greenish tinge. This mass contains some bands of from three inches to two feet thick, entirely of red sandstone.....	100
6. Red fine grained flaggy sandstones, interstratified with occasional thin bands of fine conglomerate. The mass is partly concealed.....	600
7. Greenish-drab red-weathering sandstones, holding thin bands of a greenish conglomerate, with pebbles of quartzite up to one inch in diameter. The sandstones contain many arenaceous plant casts, some of them three inches in diameter, all being indeterminate.....	50
8. Brick-red shaly sandstones and arenaceous shales in alternating light and dark beds.....	420
9. Reddish-brown fine grained heavy bedded sandstones, not well exposed..	460
10. Chocolate-brown and brick-red shaly sandstones in alternating bands.....	100
11. Brownish-red coarse brown-weathering conglomerate.....	45
12. Brownish-red coarse flaggy sandstone similar to the last.....	40
13. Red coarse conglomerates weathering dark chocolate-brown, holding quartzite pebbles up to six inches in diameter, and containing lenticular masses of coarse greenish-drab rusty-weathering sandstone.....	20
14. Greenish-drab coarse conglomerates, alternating with coarse greenish-drab flaggy sandstones (tile-stones) in beds of from a quarter to half an inch thick, holding many indeterminate black plant casts in the partings. .	13
15. Coarse conglomerates, with pebbles up to an inch and a half in diameter, composed entirely of a green quartzite and altered slate, in a coarse argillo-arenaceous cement, the whole of a green or greenish-drab colour	140
16. Red sandstones, varying in colour from chocolate-brown to Indian-red; as a rule they are fine grained, and show many carbonized plant casts, around which, for about the twentieth of an inch, the colour of the sandstone is changed to a light lemon-yellow, as if from deoxydation of peroxyd of iron.....	200
17. Coarse conglomerates of a rust-brown colour, tinged with green; they have a silico-ferruginous cement, and hold pebbles of green and black quartzite, altered slate, and a few vermilion-red jasper pebbles; quartzite and slate pebbles reach eighteen inches in diameter and predominate; they have imperfect cleavage with the bedding. The whole are deeply weathered to a rust-red, and poorly exposed.....	220
	3773

The second section is seen well exposed on the East River, between the Culton farm and the bend of the river above McKay's Brook, south of the Albion mines. It is also in descending order.

SECTION 2.

MEASURES ON EAST RIVER ABOVE THE ALBION MINES.

	<i>Fect.</i>	Measures, East River above Albion mines.
1. Gray greenish-drab and Indian-red fine grained sandstones, interstratified in beds of from one to three feet in thickness.....	100	
2. Indian-red compact sandstones, with partings showing many small scales of mica. The rock weathers greenish and is much split with cleavage planes.....	170	
3. Dark Indian-red arenaceous shale.....	10	
4. Green compact sandstones with micaceous partings, interstratified with several bands of fine grained compact red sandstone.....	50	
5. Indian-red compact and shaly sandstones in alternations.....	140	
6. Red highly calcareous sandstones, which in weathering become mottled with patches of greenish-gray.....	230	
7. Chocolate-brown shaly fine grained non-calcareous sandstones.....	18	
8. Red and green sandstones in alternate beds of from five to eight feet thick.	47	
9. Indian-red compact calcareous sandstones.....	160	
10. Red shaly sandstones. This mass contains several patches or lenticular beds of conglomerate with a red argillo-calcareous cement holding green quartzite pebbles up to three-quarters of an inch in diameter. The thin shaly beds show ripple-mark.....	25	
11. Sap-green very compact and tough fine grained calcareous sandstone.....	6	
12. Green and greenish-gray fine grained compact sandstones, much split with cleavage planes.....	18	
13. Red compact sandstone.....	45	
14. Greenish compact sandstone.....	10	
15. Red and greenish sandstones in alternating bands.....	40	
16. Red fine grained non-calcareous sandstone, with some shaly beds.....	315	
17. Whitish-green coarse sandstones, which at the base become very coarse and pass into a calcareous conglomerate varying from two to six inches in thickness with limestone pebbles up to one-third of an inch in diameter.....	20	
	<hr/> 1402	

The lower portions of the Millstone Grit hold beds of ferruginous limestone, their thickness varying, where examined by me, from five to twenty feet, the general character of which may be exemplified by that of one seen on the East River, just above McKay's Brook. This is a compact limestone of a white colour, mottled with ochre-red argillaceous patches which weather to a deep chocolate-brown.

White limestone.

At McKay's saw-mill, near the New Glasgow and Hopewell road, occur masses of an impure limestone of a deep Indian-red colour, weathering chocolate-brown, mottled with patches of a greenish tinge; of a coarse light greenish-drab rusty-weathering sandstone; and of a peculiar calcareous conglomerate or nodular limestone of a greenish-grey colour, weathering brown, the pebbles or nodules of limestone varying from one eighth to one half of an inch in diameter.

Impure limestone.

Nodular limestone.

Not far west from New Glasgow there are narrow exposures of strata belonging to this formation, but as these are believed to exhibit a want of

conformity with the formation which is to follow they will be more particularly alluded to further on. Other exposures occur further to the west on the south flank of Waters's Hill, and on McCulloch's Brook, and it seems probable that these may belong to outlying patches resting on the Devonian series.

These apparently isolated portions seem to dip to the south and south-west, pointing to the Productive coal measures but a short way in front of them, from which, however, they are separated by a great fault, and they may have originally belonged to a continuous mass rising from beneath the coal measures on the north side of the synclinal in which these are situated.

Probably derived from such isolated portions of Millstone Grit are many boulders of mottled-red and green sandstone found in pits and cuttings near the Smoky-town road, and beneath a red drift on the Intercolonial Company's railway, just south of the bridge over Waters's Brook, a conglomerate of this series is met with holding pebbles of greenish quartzite and white quartz.

By far the largest area occupied by the rocks of this formation, in so far as examined, is bounded on the west by the Middle River, on the south by the Fox-brook road and extends eastward to the old Hopewell road as far as McNaughton's mill-pond on the upper part of McCulloch's Brook, and a straight line coinciding with a fault which runs N. 33° W. from the mill-pond through the village of Westville to a point in the neighbourhood of McCulloch's Brook about one half mile from the Middle River.

In this area McLeod's Brook, which joins the Middle River nearly half a mile above Alma mills, has a general upward course, somewhat oblique to the strike of the strata, of about S. 20° E. as far as Oliver's mill, a distance of two miles and three quarters, crossing the Gairloch road about a mile short of this measure. The strata between Alma mills and Oliver's mill appear to be arranged in two synclinal forms, a deep one on the north of the Gairloch road bridge, the east and west axis of which would approach the Devonian rocks already described, and a shallow one to the south, the axis of which may be half way to Oliver's mill.

The rocks which have been given in Section 1, form the south rise of the north synclinal, where they have a direct transverse breadth of about a mile and a quarter, with angles varying from 20° to 43° , and a portion of these may be repeated in the south synclinal. The strata exposed at Oliver's mill-dam dip S. 57° W. $< 86^{\circ}$, and appear to be the vertical measures of a considerable dislocation, and about a quarter of a mile to the south of this mill a great east and west upthrow fault is supposed to run through the country, but south of its position the strata of this formation appear to constitute the subsoil for a mile and a-half to the Fox-brook road. It is probable that these may be lower than the strata of the McLeod's Brook sec-

Outlying
patches.

Fault.

Largest area of
Millstone Grit.

McLeod's
Brook.

Oliver's mill.

Synclinals.

Rocks of Sec-
tion 1.

Faults.

tion, but whether they are so or not, Section 2, exposed on the East River from this dislocation to the turn of the river above McKay's Brook may be considered as representing them wholly or in part. The direct breadth of the strata included in this section is about thirty chains in a bearing N. 10° E., with angles of inclination varying from 40° to 60°, the top of the exposed section being at the line of the fault which would cross the Nova Scotia railway about one and a-half miles south of Coal Mines station.

3. NEW GLASGOW CONGLOMERATE.

On the west bank of the East River, at the New Glasgow bridge, there is exposed a series of coarse and fine conglomerates with occasional sandstones of colours varying from Indian-red to chocolate-brown. As a rule the coarser conglomerates are more common at the bottom, the finer at the top; but they both consist of the same materials, with a difference only in the size of the pebbles, which in the finer conglomerates do not exceed a quarter of an inch in diameter.

In the coarser beds however the inclosed masses are of all sizes up to three feet in diameter, and they are, with very few exceptions, derived from the rocks of the Millstone Grit, those of red sandstone and red shale predominating, while with them all the green, greenish-drab, chocolate-brown and mottled grey and brownish sandstones, with calcareous conglomerates and nodular and other limestones, have been recognised as constituting the mass. The only other pebbles are a few of quartzite and conglomerate of the Devonian rocks.

These masses are inclosed in an argillo-arenaceous cement, holding a good deal of calcareous matter, which sometimes shews itself as a white crystalline calc-spar holding the pebbles together. The colour of the cement is an Indian-red, and this has served more or less to tinge the whole mass. The sandstones are exemplified by two beds of five feet each, of a shaly character and brick-red colour, which are seen at a distance of seventy and 120 feet respectively from the base of the section; but thinner lenticular masses and partings of red and dark-brown colours are common.

These rocks are visible along the margin of the river for a distance of 300 yards, with a direct breadth across the stratification of 610 feet, with a general dip of N. 10° W. < 35° — 50°, giving a thickness of 450 feet; but on the opposite side, as you are aware, similar rocks stretch much farther down the river and greatly augment the volume of the formation to which the locality has served to give a name.

New Glasgow
conglomerate.

Pebbles from
Millstone Grit.

Pebbles from
Devonian rocks

Calcareous
matter.

Breadth
exposed at new
Glasgow bridge

are due and I would especially acknowledge my obligations to the following gentlemen, for the information they have so freely given me :

Mr. H. Crosskill, Assistant Provincial Secretary ; Mr. Avard Longley, Chief Commissioner of Railways of the Province ; Mr. J. Rutherford, M.E., Provincial Inspector of Mines ; Mr. W. A. Hendry, Deputy Commissioner of Crown Lands ; Mr. James Hudson, M.E., Chief Manager General Mining Association of London ; Mr. Jesse Hoyt, General Agent of the Acadia Coal Company of New York, U. S. ; Mr. James Dunn, General Agent of the Intercolonial Company of Montreal ; Mr. Truman French, Agent of the Nova Scotia Coal Company ; Mr. J. P. Lawson, Mining Engineer, New Glasgow ; Mr. J. B. Moore, Contractor for the Intercolonial Coal Company's railway ; Messrs. Hanning, Civil Engineers, in charge of the construction of the same railway ; Mr. William Barnes, Mining Engineer of Halifax ; Mr. R. G. Haliburton, Col. R. B. Sinclair, Mr. L. R. Kirby, of Halifax ; Mr. Daniels, of Pictou Mining Company ; Mr. W. B. Leather, C. E., of New Glasgow ; Mr. A. P. Ross, of Pictou ; and Mr. J. Weir, of Pine-tree Brook.

Especial attention is called to the kindness of Messrs. Hudson, Hoyt and Dunn. At the Albion mines I have not only had Mr. Hudson's permission to examine and copy many valuable records and drawings, but he has presented the Survey with complete copies of his extensive underground plans, copies of drawings and specifications of machinery, and of private surveys made for the General Mining Association. By his permission, most satisfactory information was given me in my examination of the machinery by Mr. Thomas Blenkinsop, engineer, and of the underground work by Mr. William Hall, underviewer, and both of these gentlemen I would especially compliment on their admirable management of the works under their charge. I would also remark that to the skill of Mr. Thomas Rutledge, of the same company, we are indebted for the admirable set of drawings presented by Mr. Hudson.

At the Acadia collieries also, I have been allowed by Mr. Hoyt full access to the company's records and plans, and am indebted to him for the aid of men, and for much verbal information useful in my survey. Information concerning machinery and underground work, has been freely supplied by Mr. William Blacker, general overman, as also much information of a general character. I would also acknowledge courtesies of a general character received from Mr. J. W. Clendenning of New York, President of the Acadia Coal Company, who was kind enough to allow me office room in the company's building. In the examination of the Intercolonial Company's works and area, I have been materially aided by the courtesy of Mr. Dunn, who furnished plans, records and information. By his instruction, Mr. James Wilkes, underviewer, and Mr. Joseph

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1. Pre-Carboniferous.
2. Millstone Grit.
3. New Glasgow conglomerate.
4. Productive coal measures.

Rocks observed

These rocks I now propose to describe, and will then treat of their distribution in this region.

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Pre-carboniferous.

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GEOLOGICAL SURVEY OF CANADA.

	<i>Ft. In.</i>	<i>Ft. In.</i>
.....	1 4	
.....	4 3	
l.....	0 2	
orked at the Foord pits).....	20 6	
.....	8 4	
	<hr/>	34 7
a underlay; the thickness is not stated in the t here given is not fully exposed.....	1 9	
eous shales, with many bands of ironstone of lf to three-quarters of an inch in thickness, and ro bands of arenaceous shale of about two or thick, of a dark gray color.....	144 6	
aceous shale].....	1 10	
	<hr/>	148 1
ism.		
.....	0 2	
.....	3 7	
.....	1 1½	
ality.....	3 5½	
.....	0 8½	
.....	3 9	
.....	0 11½	
.....	3 4	
.....	5 10	
	<hr/>	22 11
sealed, and no pit records.....	98 0	
aceous shale	8 8	
	<hr/>	106 8
be good.....		5 7
sealed, probably shales, and fireclays with thin dstone.....	61 2	
.....	9 1	
16	1 0	
8.....	4 1	
.....	6 4	
eous shale	4 6	
.....	2 9	
eous shale.....	0 10	
.....	2 3	
16	1 4	
ns shales.....	6 2	
.....	0 3	
arbonaceous shale.....	7 6	
ne.....	0 6	
eous shale	5 3	
	<hr/>	113 0

bed from the Foord pit record.

n from Mr. Hudson's record of the Dalhousie downcast shaft.

n from Mr. Poole's journal.

	<i>Ft. In.</i>	<i>Ft. In.</i>	
<i>Parris seam.</i>			<i>Purvis seam.</i>
45. Coal coarse and impure ; it increases to five feet six inches one mile west.....		2 8	
46. Underclay with <i>Stigmaria</i> , a light colored fireclay.....	0 10		
47. Compact gray sandstone.....	4 5		
48. Fireclay	5 2		
49. Hard sandstone.....	2 7		
50. Fireclay	19 9		
51. Blue (bluish-gray) fireclay.....	4 0		
52. Compact sandstone	5 7		
53. Blue fireclay	6 5		
54. Compact sandstone	0 5		
55. Shale.....	0 5		
56. Fireclay	0 4		
57. Compact sandstone.....	4 2		
58. Fireclay.....	5 0		
59. Measures unknown.....	1 6		
60. Black argillaceous shale.....	7 2		
61. Fireclay mixed with coal (?)	7 7		
62. Fireclay with <i>Stigmaria</i>	5 8		
63. Bluish-gray flaggy sandstone.....	2 6		
64. Fireclay	0 3		
65. Gray sandstone.....	0 8		
66. Fireclay.....	11 8		
67. Black shale*	2 3		
68. Measures unknown : from poor exposures they are believed to be fireclays and thin beds of sandstone, generally of a yellowish-drab or brown color.....	31 8	130 0	
<i>Fleming seam.</i>			
69. Coal of a fair quality.....		3 3	<i>Fleming seam.</i>
70. Black carbonaceous shale		4 3	
<i>McGregor seam.</i>			<i>McGregor seam</i>
<i>Upper coal.</i>			
71. Good coal. First Bench.....	1 9		
72. Dark brown arenaceous fireclay parting.....	1 0		
73. Good coal. Second Bench.....	3 0		
<i>Bottom coal.</i>			
74. Impure Coal.....	1 4		
75. Good coal.....	0 10		
76. Impure coal	0 8		
77. Good coal.....	1 0		
78. Black carbonaceous shale	0 6		
79. Good coal.....	1 6	11 7	
80. Measure unknown, said to contain an impure coal seam of con- siderable thickness, not opened.....	186 0		<i>Impure coal seam.</i>
81. Sandstone.....	2 8		
82. Fireclay.....	9 2		
83. Brown fireclay and brown carbonaceous shale.....	9 2		
84. Black highly carbonaceous very compact shale.....	4 7	211 7	

* Nos. 81-87 are reduced from trial pits Nos. 1 and 2.

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	<i>Ft.</i>	<i>In.</i>	<i>Ft.</i>	<i>In.</i>
<i>tellar coal seam.</i>				
d coal.....	1	4		
lar oil coal.....	1	10		
minous shale. <i>Oil shale bench</i>	1	10		
			5	0
erclay not stated, included in the next (89)				
ick carbonaceous shale.....			15	2
ure coal.....			11	0
lowish-drab arenaceous underclay, weathering quickly to light brown colour and holding <i>Stigmaria</i>	8	0		
at brown compact fine-grained sandstone.....	3	0		
asures concealed.....	66	0		
ht brown fine grained very compact rusty-weathering sandstone.....	3	6		
ht brown fine grained sandstone, split with cleavage planes	30	0		
			110	6
crop only shows; it has never been opened, but its thickness is probably about.....			2	0
asures concealed, apparently light drab fireclays and sandstones.....			75	0
as has not been proved; it is an impure coal at the crop, the thickness is estimated at.....			10	0
ht yellowish-drab arenaceous underclay with <i>Stigmaria</i> ..	15	0		
asures concealed.....	18	0		
lowish compact sandstone with <i>Stigmaria</i> (?), weathering brownish-yellow and containing black shaly partings....	10	0		
asures concealed.....	15	0		
			58	0
n at the crop; the thickness is unknown, say.....			0	6
asures concealed.....	5	0		
rplish or dull claret-red very compact sandstone; one layer is eighteen inches thick.....	4	0		
asures concealed; one or two exposures of arenaceous fire-clay of a yellowish-drab color are seen.....	26	0		
			35	0
is is a very small unproved crop, and may be about.....			0	6
llowish-drab sandstones; and fireclays alternating with one another, some of the fireclays weathering to a reddish tinge. These beds are partially concealed.....	23	0		
ret-red compact fine-grained sandstone, much split in the cleavage planes.....	3	0		
ght brownish or rust colored fine grained soft sandstone, with false bedding and cleavage joints.....	5	0		
ght brown sandstone of a similar character, partially concealed.....	8	0		
			39	0

-90 are reduced from records. Nos. 91-120 are taken from exposures.

	<i>Ft. In.</i>	<i>Ft. In.</i>	
<i>Seam F.</i>			<i>Seam F</i>
112. Impure coal seen at the crop, and from the width of the crop estimated at.....		4 0	
113. Brownish-yellow arenaceous underclay with <i>Stigmaria</i> , passing downwards into a soft crumbling sandstone of the same colour.....		9 0	
<i>Seam G.</i>			<i>Seam G.</i>
114. Coal not proved, estimated at.....		2 0	
115. Measures partly concealed, apparently yellowish fireclays....	13 0		
116. Measures concealed; the drift shows the wash of a coal seam.	11 0		Coal wash.
117. Measures concealed, including two very indistinct crops of coal seams of small size.....	72 0		Two small seams.
118. Brownish-yellow crumbling arenaceous fireclay with <i>Stigmaria</i> , immediately overlaid with a little coal wash, as if of a coal seam of an inch or two in thickness.....	7 0		Coal wash
119. Dull claret-red sandstone, very compact and fine grained....	7 0		
120. Brownish coarse grained sandstones and arenaceous fireclays alternating with one another, badly exposed, estimated at..	40 0		
		150 0	
Total*		2452 11	

No single section or column can be given which will fairly represent the measures of the entire coal field, as very considerable changes occur in the character and size of the coal seams, and changes of a remarkable character are seen throughout the field in the rocks. Special descriptions of the coal seams at the different collieries, with one or two pit sections, will illustrate this. Perhaps the most remarkable instance in this coal field of a complete change in the character of the measures is that which occurs in the 400 feet of strata immediately overlying the Main seam, between the Foord pits near the East River and the Forster pit, about a mile to the west. At the Foord pits, as will be seen by reference to the general section, the Main seam is overlaid by upwards 1,000 feet of black and brown shales, the lower portion of which is principally carbonaceous. Tracing this mass of black shales west, on Coal Brook we find the shales less carbonaceous, and many interstratified bands of clay iron-stone are included in the lower portion; at the Dalhousie pits, they are the same, with some arenaceous black shales included; and on the Forster pit railway, some very thin bedded, light drab sandstones become interstratified. No exposures exist between the Dalhousie and Forster pits, but as we go west we may trace, by means of the rocks brought into the underground working by a *crush*, a gradation from argillaceous black shales and iron-stones, through arenaceous black shales and arenaceous light coloured shales with

Horizontal changes in measures and coal seams.

Changes between Foord & Forster pits.

* Between the Deep and McGregor seams there are but few natural exposures, and as neither the Third nor Purvis seams are open at the present time, the general thicknesses as given, are liable to alteration on future explorations.

GEOLOGICAL SURVEY OF CANADA.

aceous partings, to thin bedded sandstones with similar black argillaceous partings; while at the Forster pit we find the ascending section, including many feet of compact sandstone, of a white colour.

SECTION 5.

MEASURES INTERSECTED IN THE FORSTER PIT.

	<i>Ft.</i>	<i>In.</i>	<i>Ft.</i>	<i>In.</i>
grey sandstone, the post of the miners.....	13	9		
ish drab fireclay varying to brown.....	2	3		
argillaceous shale		6		
ish-drab fireclay.....	2	3		
argillaceous shale	19	9		
brownish-grey shaly sandstone, passing into argillo- maceous shale holding calcareous matter; it weathers on to a rust-brown colour.....	8	6		
grey argillaceous shale	2	8		
grey sandstones and shales similar to 6.....	20	2		
sandstone, sometimes shaly, often compact, in beds of from three to four inches. The shaly portions have some black carbonaceous partings	1	2		
brownish-grey sandstones and shales similar to 6.....	32	4		
semi-carbonaceous shale.....	81	0		
carbonaceous shale	54	0		
brownish argillo-arenaceous shales. They are com- posed of interstratified layers of black and white arenaceous shales, very thin and loosely bedded. They are strongly calcareous, and in similar shales in other parts of the field, have been seen small lenticular masses of pure white lime- stone up to an eighth of an inch in thickness and three or four inches in length.....				
carbonaceous shale, the black bed of the miners.....	6	3		
grey argillo-calcareous shale, containing a great deal of iron. It weathers to a very bright iron-red on surfaces of deposition, and rust-brown on fractures. Some portions of this mass may prove a workable ironstone...	54	0		
			391	13
thin coal.....	2	3		
thin coal.....	2	3		
thin brown arenaceous fireclay parting	1	1		
thin coal.....	8	9		
thin brown arenaceous fireclay.....	2	9		
thin coal. This part is worked.....	19	9		
			36	10
			428	9

Productive coal measures in the district under consideration are between two great upthrow faults on the north and south sides, and are limited on the west by a third. These faults have already been partially alluded to in the description given of the distribution of

the lower rocks. One of the dislocations, to which you have given the name of the North fault, passes through the town of New Glasgow, where, on the west side of the river, it brings the lower portion of the coal measures against a small area of Millstone Grit deposits, just at the base of the New Glasgow conglomerate. Thence it passes in a course of S. 88° W. near to the north-west corner of the General Mining Association's area, in which vicinity it turns more to the south-west, and from the Smoky-town road to the Middle River its course is about S. 72° W. In this bearing, to within a mile of the Middle River, it brings the Devonian series, with outlying patches of Millstone Grit, against the coal measures, but farther on its effect is diminished by the fault forming the western boundary of the coal field. This disturbance it is proposed to designate as the West fault. The general course of this dislocation, and its position, as well as the position of the great southern upthrow which you have named the South fault, have been indicated in the description of the limits of the principal areas of Millstone Grit.

Within these boundary lines the coal measures are arranged in two synclinal forms, the axes of which, about a mile apart, run in a general east and west direction. The first and larger of these will be designated the Albion synclinal. It has perhaps a subordinate undulation near its centre, but the exposures which would seem to indicate this may be brought into place by a considerable fault known to exist in their vicinity. The Albion synclinal extends laterally from the town of New Glasgow to the Albion and Acadia (Fraser) mines, near the East River; and to the south of this is the second trough, to which will be given the name of the Bear-creek synclinal. Both of these are limited at their western ends by the West fault, and while the area of the workable coal in the Bear-creek synclinal is limited to the east by a dislocation, probably not throwing out the lower portion of the coal measures entirely, the Albion synclinal* extends eastward across the East River, beyond the region of my examination.

The only important group of coal seams included in the measures on the west side of the river, is that of the general section (Section 4), and as these seams have been most extensively worked, and are therefore best known at the Albion mines near the East River, it would seem best to take these workings as a starting point in describing the general distribution of the group.

From the oldest workings on the west bank of the Little branch of the East River the out-crop of the Main seam, which in these workings has a dip of N. 22°—30° E. (or N. 45°—53° E. Magnetic) <18°—23°, crosses

* This is the Middle synclinal, and the subordinate undulation gives the North synclinal of the previous Report.

the East River, and curving slightly south-eastward enters the area of the Pictou Mining Company. About half-a-mile in a bearing S. 70° E. from the west bank, a slope was sunk by the company mentioned upon the Main seam; but the coal proving of inferior quality the workings have been abandoned. The dip is here N. 35° E. < 19°, and a section of the seam as taken by Mr. Thomas Lawther when in charge of the mine as overseer, and given me by him is as follows:—

	Ft. In.
Shaly coal, known as <i>strong coal</i> by the miners.....	2 0
Coal and black carbonaceous shale.....	8 0
Shaly coal.....	2 0
Black carbonaceous shale, with coaly matter in the partings.....	10 0
Shaly coal, worked.....	1 0
Good coal, worked.....	2 0
Shaly coal, worked.....	1 0
Poor coal, not worked, about.....	12 0
	38 0

About twenty-eight chains from the slope, in the bearing S. 73° E. and 108 yards from the crop across the strike of the strata, which is here S. 5° E., a pit was sunk 350 feet to the top of the Main seam, and a few feet into the coal, which proved of inferior quality, in consequence of which, after boring through the seam, this shaft also was abandoned. As the strata sunk through in this pit shew a change in the character of the measures between this point and the Foord pits, equally remarkable with that between the Foord and Forster pits, the following section is given after an examination of the pit *débris* in company with Mr. Lawther, who had charge of the sinking, and has furnished the record of the thicknesses of the different beds:—

SECTION 5.

MEASURES INTERSECTED IN THE PICTOU MINING COMPANY'S PIT ON THE MAIN SEAM, GRANT'S FARM.

	Ft. In.
Black carbonaceous and argillaceous shales in alternating bands; the only fossil observed is <i>Cordaites borassifolia</i>	94 0
Dark gray sandstone alternating with white arenaceous shales having black carbonaceous partings, and showing many indeterminate carbonised plants; in some beds the partings exhibit ripple-marks. In weathering, the arenaceous shales do not change their colour, while the sandstones weather different shades of gray, through brownish-gray to dark brown, some bands shewing a reddish tinge. The whole mass contains occasional thin bands of clay ironstone.....	58 0
Black argillaceous shale.....	101 0
Dark gray close grained sandstones with white arenaceous shales similar to the second bed of the section; near the middle of the mass a band of dark gray sandstone was sunk through of an exceedingly close grain which weathers to a dull orange-drab.....	37 0

	<i>Ft. In.</i>
Black carbonaceous shale.....	7 0
Dark gray heavy bedded sandstone interstratified with dark gray shaly sandstone having some black carbonaceous partings.....	14 0
Black argillaceous shale.....	1 0
<i>Main Seam.</i>	<i>Ft. In.</i>
Coarsely laminated coal, known as <i>coarse coal</i> by the miners	2 5
Dark gray fireclay full of <i>Stigmaria</i>	2 10
Shaly coal and black carbonaceous shale.....	9 6
Coarse coal.....	1 7
Dark gray fireclay with <i>Stigmaria</i>	2 4
Bad coal, bored through.....	6 7
Dark fireclay, bored through.....	3 0
	<hr/> 28 3
	<hr/> 340 3

Immediately to the rise of this shaft a trial-pit has been sunk on the crop of the Main seam, but beyond this the seam has not been traced southward. In a few chains however it is probably thrown considerably to the eastward by a fault having an east and west bearing and producing an upthrow on the south side. To the south of this fault one coal seam only is known; it is on the land of Mr. Donald McLeod, and with a thickness of eight feet, strikes S. 15° E., the dip being eastward at a moderate angle, but it is not at present known what coal seam of Section 4 this one represents. The dislocation which brings it into place will be designated as the McLeod fault.

In the triangular area between the crop of the Main seam and the dislocation just mentioned, bounded to the west by the East River, only one seam has been opened. It is the Deep or second seam of the Albion group, on the crop of which a trial-pit was sunk by the Pictou Mining Company; but the coal is said to be of very poor quality.

The crop of a seam underlying this is seen on the east side of the Springville road, in a small stream crossing the road about half-a-mile to the south of the crop of the Main seam, but its position in the coal series cannot be stated with certainty at present, as it lies to the south of the McLeod fault. Beyond this disturbance the measures are supposed to turn slightly to the west of south, and then again curving round to a south-eastward strike, they will, if not lost on some dislocation as yet unknown, be finally cut off by the great South upthrow fault of McGregor's Mountain. The westward curve of these measures shows the existence of a shallow synclinal on the eastern prolongation of the axis of the Bear-creek synclinal* presently to be described.

* This synclinal appears to correspond with the South synclinal of the previous Report.

GEOLOGICAL SURVEY OF CANADA.

on the west side of the East River, the workable seams from McGregor are known near the river bank. The underground Albion mines prove the exact position of the Main and are about one mile and a quarter west from the earliest work-se, now known as the Burnt mines, the strike and the angle are regular to the Dalhousie and Cage pits, where the dip is 30° at the crop of the Main and Deep seams in the bed of the river; thence the line of the crops of these seams turns to a more regular dip, the dip at the crop of the Main seam to the rise of the river being about $N. < 30^{\circ}$. Farther west the strike curves slightly westward, while the angle of inclination is considerably less; at the McKenzie pit on the Deep seam near McCulloch's it is $N. 23^{\circ} W. < 15^{\circ}$.

The Purvis seams are known near the river by trial-pits sunk by the Coal Company, and to the west nearly as far as McCulloch's Third seam slope near the north line of the Fraser area, and from the north-west corner-post; and by the Purvis pit on the side of the old post road to the Middle River, about twenty-toward of the McKenzie pit.

The McGregor seam has been traced from its out-crop on the bank of the river about 115 chains west by trial-pits and the workings of the liery, and a crop on McCulloch's Brook is believed to show the seam still farther west.

The extensive working of the Oil-coal or Stellar seam is from the face of the Acadia Coal Company, near the crossing of that company's road on Coal Brook, from which opening its crop is known eastward. It is near the New Glasgow and Hopewell road, about forty-five chains east, where the out-crop of this seam approaches the run of the diolite, has been called the McLeod fault, and it is probable that it extends much farther in a south-east direction. To the west of this the course of this seam has been proved to the Stellar coal slope on the east bank of McCulloch's Brook, where it is shewing this position to be near the axis of the anticlinal Albion and Bear-creek troughs. The seams and the associated shales are placed below the Stellar in Section 4 are seen only on the Coal Company's railway, the lowest appearing in the railway being about twenty-five chains eastward from the McCulloch's Brook, immediately to the south of which exposures runs the McLeod fault; up still lower rocks. Their position in the Carboniferous is not accurately known.

Farther to the west of McCulloch's Brook, and nearly parallel to it, from the Stellar mine to the McKenzie pit, a considerable

dislocation exists, having a run S. 22° E, with a western downthrow; the extent of this is not exactly known, but it would appear to be about 1600 feet where the crops of the Albion group of seams are lost. This dislocation will be called the McCulloch-brook fault. A short distance to the south of the Stellar mine the break in this fault is considerably increased by that of the McLeod fault. It has already been observed that the measures to the south of the McLeod fault have not been sufficiently examined to enable their horizon to be stated with certainty, and but few exposures exist between this fault and the great South fault; the rocks however, where seen, appear to be light drab and reddish-grey sandstones with many thin beds of black flaky fireclay, some of the sandstones weathering to a deep Indian-red, somewhat resembling the red sandstones of the Millstone Grit series. The general aspect of these strata, however, is not precisely like any mass of rock known to belong to that series, and as the lowest portion of the strata in question, where exposed near the East River, have a resemblance to some beds of yellowish-white sandstone seen on the right bank of the river below New Glasgow bridge, in geological position immediately overlying the New Glasgow conglomerate, we may provisionally consider the rocks in these two places as occupying a proximate horizon, namely that of measures between the conglomerate and the workable coal seams.

McCulloch-brook fault.

Red Sandstones.

Geological horizon.

Between the two bounding faults these strata are arranged in a shallow synclinal form corresponding with that to which, as you have informed me, you have given the name of the South synclinal on the east side, and the same as that designated by me as the Bear-creek synclinal on the west side of the East River.

The McCulloch-brook fault cuts off the crop of the Main seam near a small water run, a few chains to the west of McCulloch's Brook. On the down-throw side of the break the general dip of the measures is changed but little near this point, but on proceeding south we find near the southeastern portion of the Carmichael area of the Acadia Coal Company that the strata pass over an anticlinal, the dip becoming flat, and then southerly, while in the centre of the eastern portion of the Bear-creek area of the Intercolonial Coal Company the measures again flatten, and finally assume a northerly dip as we go south. The anticlinal near the south line of the Carmichael area is the continuation westward of the form on the north dip of which the Albion mines are situated, while the synclinal is in continuation of your South synclinal, and is the form to which I have given the name of the Bear-creek synclinal.

Break in Main seam.

The strata which are brought up by the fault against the Main seam of the Albion mines are believed to represent a series of black shales above the Three and a-half feet seam at the summit of Section 4, which have been

Three and a half feet seam.

observed elsewhere only to the east of the East River on Potter's Brook. The angles of inclination to the west of the fault are not sufficient to bring the Main seam and those below it to the surface, and therefore in tracing the McCulloch-brook fault to the south-eastward, out-crops of these seams do not appear until the south rise of the Bear-creek synclinal is reached, where they are supposed to leave the fault with a westerly strike. The exact line of this fault is not known on the No. 3 area of the Acadia Coal Company, which lies to the south of the Fraser area, but it is believed to continue in the general course of S. 22° E., which it is known to have near the Stellar mine.

On the No. 3 area the black shales overlying the Main seam have been proved by a few trial-pits, but no coal seam has been found between the McCulloch-brook fault and the stream itself on the south rise of the Bear-creek synclinal. On this brook, on the Culton area of Messrs. Sinclair and Haliburton, about six chains south of the north line of the area, an opening has been made upon a coal seam locally known as the Culton seam. Here the dip is N. 15° W. < 15°, which is about the direction of the adit or slope upon the seam, which, according to Mr. Joseph Richardson, who was in charge of the prospecting here, was but two inches in thickness at the out-crop, increasing in forty-five feet to three and a-half feet of very good coal. To the dip of this slope, in a position not now accurately known, a bore was put down upon this seam, which Mr. Haliburton informs me proved its thickness to be six feet, the coal being of very good quality. This seam at the Culton adit, as the slope was called, was directly overlaid by a thin band of highly carbonaceous black shale, known as *oil bat* by the miners, and then by a band, about six inches in thickness, of black carbonaceous shale, full of *Spirorbis* and *Cythere* shells. In the remains from the slope numerous fossils were found, among which may be mentioned well preserved teeth, spines and scales of *Diplodus*, with *Cordaite borassifolia* and impressions of *Lepidodendron*, *Antholites* and *Cardiocarpus*, not specifically determined.

A large number of pits and bore-holes have been sunk in the great mass of black carbonaceous and argillaceous shales which overlie this seam by Messrs. Sinclair and Haliburton and the Intercolonial Coal Company, but no seam of coal has been found. This, together with the fact that it is shewn by the general structure to be in all probability the Acadia seam presently to be described, which again I believe to represent the Main, leads me to the supposition that the Culton seam is the representative of the Main seam of the Albion mines, its small size being partly due to the presence of a fault known to exist in the Culton adit, though there may also be a thinning of the seam in this direction.

One underlying seam is said to have been proved, but of its size, char-

been kept, though I am informed by a work-
 ere in which it was found that twelve feet of
 ll lower seams may crop out in the interval
 a fault, but no exposures of coal are seen,
 y deep (its thickness occasionally reaching
 w attempts have been made to find them,
 lways resulting in failure.

Twelve feet
 seam.

t a few yards to the westward of the Cul-
 ture would lead us to expect that at about
 a crop would come against the West fault;
 by Messrs. Bürkner and Ellershausen,
 , and two feet of a seam were found in the
 n which was undoubtedly the West fault.

West fault.

id of the Bear-creek synclinal the out-crops
 West fault until, at about thirty-six chains

the bearing N. 83° W. from Messrs. Bürkner and Ellershausen's pit,
 a large seam of coal is found in trial-pits sunk by Mr. W. Barnes for the
 Intercolonial Coal Company, which is known locally as the Acadia seam,
 and which is in all probability the representative of that of the Culton adit.
 The out-crop of this seam leaves the West fault with a general dip of S.
 10° E. about 400 yards south of the slopes at the Drummond colliery, and
 curves gradually north and to the west of north on the anticlinal between
 the Bear-creek and Albion troughs, till the southern line of the Acadia
 Company's Carmichael area is reached. Thus far its crop has been accu-
 rately ascertained by crop trial-pits and the underground workings from the
 Drummond colliery. At this colliery the dip is E. (or S. 67° E. Magnetic)
 < 16° at the surface, the dip at the north line of the area being about N. E.
 and the strike N. 41° W. (N. 18° W., Magnetic) is preserved across the
 Carmichael (Acadia) area with great regularity as proved by the under-
 ground levels from the Acadia (west) colliery, where the dip is N. 49° E.
 20° near the surface. Thence it is traced by pits to the Nova Scotia
 Coal Company's slope where the dip is N. 42° E < 28°. Here the strike
 turns more to the west for eighteen chains, which is the distance that it has
 been accurately traced. A short distance farther this strike will intersect
 the West fault, and the seam will be again concealed. This seam of coal
 is about eighteen feet in thickness at the Intercolonial, Acadia and Nova
 Scotia collieries.*

Drummond
 colliery.

Acadia colliery.

Nova Scotia
 colliery.

As has already been stated it would seem most probable that this seam
 is the representative of the Main seam of the Albion mines, somewhat
 reduced in thickness and changed in character, but still furnishing an

Seam equiva-
 lent to Main
 seam.

* Sections of this seam at different points will be found included in the descriptions of
 the collieries.

excellent quality of coal. Opinions have differed very much as to which of the lower seams it should be identified with, many miners advocating identification with the Deep or the McGregor seam. Many reasons exist for supposing it to be the Main, and I consider that the following facts will remove all doubts on this subject :

Barren mea-
sures over
Acadia seam.

Fossils.

By reference to Section 4 it will be seen that the greatest mass of barren measures between the Main and McGregor seams consists of the strata between the Main and Deep seams, amounting to rather more than 148 feet, while above the Main seam barren measures exist amounting to over 1100 feet. Numerous trial-pits have been sunk on the measures overlying the Acadia seam, in which no trace of coal has been found to my knowledge, and a bore-hole has been sunk to the Acadia seam about fifteen chains from the Drummond colliery in a bearing S. 67° E. by Mr. Barnes, which, according to his record, proved barren black shale directly overlying the seam to a thickness of about 170 feet at right angles to the plane of the strata. These shales as seen in the Drummond colliery air-pit are remarkably like the black carbonaceous shale from the Foord pit at the Albion mines. The six inches of shale immediately overlying the seam at the Drummond colliery contains, *Spirorbis* and *Cythere* shells, *Antholites*, *Lepidodendron*, *Cordaites borassifolia*, and markings which I am informed by Dr. J. W. Dawson are *Lepidostrobus*.

Red Brook.

At the Acadia colliery no records exist for an accurate section of the strata. A short section as furnished by the record of the air-pit is given in the description of the colliery, and above this the measures obtained in the railway cuttings and in a number of pits sunk on Red Brook running north-east from the colliery appear to consist of black argillaceous shales, with some thin bands of bluish-grey argillaceous and white arenaceous shales having black carbonaceous partings, the white shales being in beds of from one twentieth to one fortieth of an inch in thickness. Farther west the measures directly overlying the Nova Scotia Coal Company's slope appear to be very thin bedded black arenaceous shales, with bands of carbonaceous and argillaceous black shale.

Seam equivalent to Deep seam.

A second seam has been found underlying the Acadia seam at about 160 feet, which probably represents the Deep seam of the Albion mines ; also a third which I believe to represent the Third seam of the Albion group. A fourth is reported, but of this no record can be obtained.

The crops of the Second and Third seams run nearly parallel with that of the Acadia seam. The Second has been proved on the areas of the three companies working the Acadia seam, and is said to be about twelve feet in thickness, of which eight feet are reported to be good coal. The coal from this seam which I have examined, however, is coarse and shaly with about 30 per cent. of ash ; but the specimens not having been taken from the

seam by myself, I cannot state that they fairly represent the entire bench of eight feet. The crop of the Third seam, being quite near the West fault, will probably be confined to a short run on the Intercolonial and Acadia (Carmichael) areas.

Continuing the course of the West fault north-westward we find no further appearances of the lower coal seams along the western boundary of the coal field, the structure indicating the deepening of the coal measure trough, and that the higher rocks are brought against the Millstone Grit series on the west side of the West fault until we approach the North fault. The position of the intersection of these dislocations is approximately shown on the map, but farther explorations may induce alterations.

The boundary of the coal field now becomes the North fault; and tracing this east, we find the altered Devonian rocks brought against barren coal measures, probably representing the black shales, with no appearance of the lower seams until the Sutherland and the Montreal and Pictou areas are reached, when the outcrops of at least a portion of the lower group of coal seams leave the fault in a north and south transverse swell on the north rise of the Albion synclinal, the curve of these crops corresponding in some degree with the opposite curve in the crops of the Albion group of seams on the south rise of the trough.

Before reaching the East River the out-crops turn back towards the fault, and meeting it at nearly a right angle, are not again seen in the region examined. The small extent of surface over which these seams can be observed, the almost entire absence of exposures, and the change in the character of both seams and including measures, combined with the high angles of dip and sharp turns in the strata, as seen on the banks of the East River, render the identification of coal seams here with those of Section 4 at the Albion mines, a matter of extreme difficulty. The region for some distance from the great North fault is also much disturbed by minor dislocations, and none of the coal seams have been sufficiently opened to show their characters when in an undisturbed position.

At present the only obtainable facts with regard to the seams at this point are in the records of the Montreal and Pictou Coal Company's trial and working-pits, a record of borings made for the Intercolonial Coal Company on the Sutherland area, and such verbal information as Mr. Haliburton, managing director of the Montreal and Pictou Company, has been able to give me concerning the underground work done by that company. The exposures on the banks of the East River give the structure of the eastern side of the transverse elevation; the Montreal and Pictou pit gives the south side and turn of the strata to a strike a little south of west; but for the western dip, we have only the records of two trial-pits, and such facts as the topography and surface rocks can furnish.

It has been supposed that the seam proved in the working-pit of the Montreal and Pictou Company represents the Main seam of the Albion mines; but the fact that coal crops are connected with measures manifestly overlying this seam a few hundred feet, together with the fact that the seam appears to be within 225 feet of another proved on the old road to Fraser Ogg's quarry, which for reasons to be given hereafter, I am inclined to believe represents the Stellar seam of the Acadia mines (Fraser area), leads me to identify the Montreal and Pictou seam with the McGregor, rather than with the Main or Deep seam, the equivalents of which, in absence of evidence to the contrary, I am inclined to think will be found to overlie it. The following facts may lead to the finding of one or both of these overlying seams. I would first remark, however, that in a region so likely to be broken by faults, mistakes in distances between seams are to be guarded against, as different exposures of the same seam, when it is thrown by faults, may be mistaken for different seams.

Seam equivalent to McGregor seam.

(1). On the south-eastern portion of the Intercolonial Coal Company's Sutherland area, a bore-hole was sunk which passed vertically through twenty feet of coal divided into two parts by four and a-half feet of fire-clay. The inclination of the strata is not stated, but it is supposed to be about 65° , which would give a thickness of about nine feet to the coal and a foot and a-half to the parting. The position of this would appear to place the seam higher stratigraphically than that of the Montreal and Pictou pit.

Nine-feet coal seam.

(2). On the west bank of the East River, near its intersection with the north line of the General Mining Association's area, there is a mass of coaly shale of considerable thickness, mixed with a black shale so highly carbonaceous as to yield a large amount of gas. It is supported by a *Stigmara* underclay, beneath which occurs the crop of what appears to be a true coal seam. This, it appears to me, may possibly represent the Main seam.

Seam equivalent to Main seam.

(3). On the same bank of the river, opposite the town of New Glasgow, a pit was sunk on a coal seam stated to be seven feet thick; this, it is said, was lost upon a fault, and as no record of the work was kept, its exact position cannot be given. At the time this was opened it was supposed to represent the Montreal and Pictou seam, but from the structure, which is well shewn on the river bank, I am inclined to think it belongs to measures several hundred feet higher.

Seven-feet seam

Provisionally considering the Montreal and Pictou seam as the McGregor, it would seem probable that the crops of the Albion group leave the North fault, with westerly dips at a moderately high angle, at some distance west of the east line of the Sutherland area, and the seam provisionally considered to be the Oil coal will be not far from this line at the fault.

Albion group of seams, in relation to the North fault.

This westerly dip is preserved by the upper portion of these seams till they approach the Montreal and Pictou corner on the General Mining

association's north line, near which a pit (No. 2 of the Intercolonial company's Sutherland area record) has proved the dip to be S. 67° W. (or magnetic) in bearing, with an inclination of about 65°. The Montreal and Pictou seam at the working pit, dips S. 48° E. (or S. 20° E. mag.) 65°; there must therefore be a very abrupt turn or a dislocation between the two pits. At the working pit the seam thus shows a run toward the northeast, and thence the structure can be given with comparative accuracy from the river exposures. These show the run of the measures to be nearly parallel with the bank of the stream, trending somewhat to the east of north until opposite the town of New Glasgow, where they all come against the North fault again, with a strike probably at about right angles to its course.

In a region so likely to be disturbed by the forces which have produced dislocation of such great extent as the North fault, records of scattered pits are always unsatisfactory, as the dip in any of these pits may be influenced by a fault, or by a sudden twist in the strata, even if a break has occurred. The structure of this immediate part of the coal field, as indicated on the map, must therefore be understood as merely general and illustrative, and liable to considerable alteration in detail from future explorations.

Provisional
structure.

The presence of the great seams of the Albion group has prevented any attempts at systematic explorations for coal beds above the barren black shales on the west side of the river. A few trial-pits, however, exist in the upper portion of these measures, but of these there is in most cases no record, and the only indications of coal there at present known are believed to belong to a bed which occurs between the black shales overlying the Main seam of Section 4, and certain black shales of Potter's Brook on the east side of the East River; the only evidences of this seam are in the pits mentioned, and a few exposures far apart from one another. This I have called the Three and a-half feet seam.

Few researches
for coal above
the black shales.

Three and a
half feet seam.

The seam is first seen in a cutting on the Nova Scotia Railway, about 10 chains north of the culvert over Coal Brook in the vertical measures of the fault; but it is here on the south rise of the Albion synclinal, and its crop is known westward about one mile by two pits, one sunk on the side of the New Glasgow and Hopewell road, near the crossing of Coal Brook, and the other on a small branch of the same brook, about one half mile west. Thence the general structure would indicate that its course would be somewhat as shown on the accompanying map, where it is represented that at the McCulloch-brook fault the crop is thrown about seventy chains south. This seam does not appear in the Bear-creek synclinal, the deepest part in this trough showing only about 800 or 900 feet from the surface of the Acadia (Main) seam. West from the McCulloch-brook fault the

Distribution.

McCulloch-
brook fault.

Axis of Albion
synclinal.

Coal crop on
McCulloch's
Brook.

An E. and W.
fault.

Coal crop near
Coal Brook.

Systems of
faults.

crop turns north-west on the south rise of the Albion synclinal, crosses the old post road to Middle River a short distance west of the Intercolonial Coal Company's railway. Thence it is not known except by a crop on the post road to Truro, near the turning to the private road running south to Horn farm. This point is shown by the structure of the measures below the seam to be nearly on the axis of the Albion synclinal, and the seam probably crosses the road nearly at right angles to its general course.

Beyond this exposure the course of the crop cannot be followed with accuracy back to the McCulloch-brook fault, and as laid down on the map it must be taken as conjectural, and as merely illustrative of the general structure. The only coal crop known on the north rise of the Albion synclinal between the West and McCulloch-brook faults was met with in laying the foundations for the Intercolonial Coal Company's railway bridge over McCulloch's Brook. This is stated to have a thickness of three feet, and it is probably the seam in question, though it is here carried eastward, and nearer to the centre of the synclinal than might have been expected, by the effect of an east and west fault presently to be described, throwing up the measures on the north side. From this position at the railway bridge the general structure would bring the crop to the McCulloch-brook fault, but this being an upthrow on the east side, the plane of the seam is carried by it above the general level of the surface, and the crop does not again appear on the north side of the east and west fault, unless it is represented on the north branch of Coal Brook, which is a considerable distance to the east, by a coal crop a few feet on the north side of the disturbance above alluded to, which it leaves for a few chains, returns to it again.

Farther eastward the north rise of this seam appears to leave the south side of the fault, and on approaching the Albion mines there are indications of its crop on the north side of the Hopewell road about two chains north of the railway bridge near Coal Brook; this, and a similar exposure of the East River at the mouth of the brook, seems to show the general course of the Three and a-half feet seam as far eastward as it is at present known. No other coal seam overlying the black shales has been observed to the west of the East River.

All the greater faults limiting or considerably effecting the distribution of the coal seams, have already been alluded to. Those affecting the underground workings in the different collieries will be mentioned farther on in the detailed descriptions of these workings but besides these many dislocations of greater or less extent traverse the Productive coal measures, though the greater number of them are of slight importance. These may be divided into three series, the first belonging to each preserving a general parallelism in their bearing

ough a few exceptions are known. They are (A) faults having a general course of N. 33° W. and S. 33° E. ; (B) faults having a general bearing E. and W. ; and (C) faults having a direction of about N. 67° E. and S. 67° W. ; besides these a fourth series (D) may be added having a course of N. 58° W. and S. 58° E., of which several examples have been known, as will be especially seen in the workings of the Deep seam at the Albion mines.

Of these minor dislocations two have been observed affecting the measures near the centre of the Albion synclinal, of which descriptions may be introduced here. The first, which may be called the Potter's-brook fault, was first noticed on that brook near its junction with the East River. It is a downthrow to the south, apparently of considerable extent, and has an E. and W. direction, the exact bearing from Potter's Brook westward being N. 86° W. It has been traced westward from the East River about a mile and three quarters, and is the same break as has already been mentioned in connection with the Three-and-a-half feet coal seam. My belief is that it will extend across the McCulloch-brook fault, which it would seem to be broken and thrown southward, and thence will be found to run across the western portion of the coal field to a point near the intersection of the North and West faults. This supposition has been induced by the fact already stated, that a fault with a southern downthrow seems to affect the crop of the Three-and-a-half feet seam between the Truro post road and the railway bridge on McCulloch's Brook. The Potter's-brook disturbance would thus belong to a more ancient system of faults than that deriving its name from McCulloch's Brook.

Potter's-brook fault.

Broken by the McCulloch-brook fault.

The effect of the second of these dislocations is seen at the railway bridge over the East River, just above the town of New Glasgow, where the measures, which, on the right bank of the river above the bridge, are seen with dips somewhat to the south of east at moderate angles, on approaching the fault are suddenly thrown round to a dip of north at a high angle. This turn to the north at this point is probably in part due to an undulation corresponding to a third or subordinate synclinal, which you have observed on the east side of the river, and which, I believe, you have named the North synclinal. But the immediate cause of the sudden turn and high angle of dip in the strata appears to be due to the fault, which has a bearing N. 67° E. at the lower end of the bridge.

Bridge fault.

ECONOMIC CONSIDERATIONS.

In the treatment of this coal field with reference to its economic importance, it would seem best to divide it up into the different mining areas as surveyed and leased by the Mines Department of the Province, giving

Economics.

under the heading of each area, descriptions of such collieries as are now in active operation, of workings which have been abandoned, and of railways built and owned by the various coal companies.

Extension of
map.

It has therefore been thought proper to extend the map designed to illustrate the region, beyond the area examined, in order to show the connection of the Productive coal field with tide water at Pictou and Merigomish harbours; and with a view of properly filling the topography, a number of roads near the town of Pictou, and a plan of that town, have been taken from a map of the county of Pictou published by Messrs. A. F. Church and Co. of Halifax.

The southern limit of the map will be the parallel $45^{\circ}.30'$ of north latitude, while northward it will extend as far as the entrance of Pictou harbour on the Gulf of St. Lawrence; east and west it will reach so far as to include the harbour of Merigomish and the valley of the West River.

The projection of the map is based upon Admiral Bayfield's determination of the geographical position of Pictou light-house at the entrance of Pictou Harbour,* and Betty Point, Merigomish Harbour †.

GENERAL MINING ASSOCIATION.

General Mining
Association.

The history of the acquisition by the General Mining Association of the Royal patent granted to the late Duke of York, giving them possession of all the minerals of the Province of Nova Scotia; of their extended working and exploration in Pictou and Cumberland counties and the island of Cape Breton, and of their final cession of the greater portion of their rights in consideration of certain facilities and franchises granted them by the Provincial Government, is too well known to need rehearsal.

ALBION MINES AREA.

Albion mines
area.

By reference to the map it will be seen that the area of three square miles, selected by this association in the coal field, is the central one of the areas embracing the Productive coal measures. It includes the crops of the two principal seams, the Main and the Deep, both of which have long been worked by the company. Till within a limited period the Albion mines, and some workings on the McGregor seam on what is now called the Fraser area of the Acadia Coal Company, constituted the only regular workings of the Pictou coal field, and upon the coal shipped by this company was established, in the first instance, the reputation of Pictou coal.

Importance of
the workings.

These workings have now reached a great importance, not only from their considerable extent, but from the number of collieries in active opera-

* Pictou light is in $45^{\circ} 41' 25''$ north lat., and $62^{\circ} 39' 19''$ west long.

† Betty Point is in $45^{\circ} 38' 29''$ north lat., and $62^{\circ} 26' 40''$ west long.

ten. and from an actual power of production exceeded by very few on this continent. Although these collieries are included under the general term of the Albion mines, it will be necessary to describe them under the following local names, indicating either districts with well marked boundaries or separate working pits: 1, Burnt mines; 2, Crushed mines (abandoned); 3, Dalhousie pit works; 4, Forster pit works; 5, Foord pit works, all on the Main seam; and 6, Cage-pit works on the Deep or Cage-pit seam.

Burnt mines.—The Burnt mines include the earliest workings from the Burnt mines. crop of the Main seam, and extend from the west bank of the East River about one-half mile northwest toward the Dalhousie pits. Although these workings have long been abandoned in consequence of a fire, I am informed that the pillars have not been crushed, and might still be taken out, should the course of trade require it.

Crushed mines.—The Crushed mines are situated to the deep of those Crushed mines just described, their extent being from the east bank of the East River northwest to the Dalhousie pits, a powerful barrier of coal being left between them and the Burnt mines.

Dalhousie pit works.—The Dalhousie pit works are at present in actual Dalhousie pit works. operation and capable of producing about 800 tons of coal per diem. The machinery at the Dalhousie Bye pit, or drawing pit, consists of one 50 horse-power beam engine, single cylinder, drawing cages containing one box or car holding 1500 lbs. of round coal, by a 4-inch flat wire rope.

The arrangements at bank, shutes and railway near the pit head are of a very complete, substantial and convenient description, and the celerity of hoisting, dumping and screening the coal at the pit head evinces a system and management worthy of imitation elsewhere. This pit has been extensively worked during the past summer, the coal raised being taken principally from the pillars.

Forster pit works.—The Forster pit is a late working of this company, Forster pit works. and during last season was only irregularly in operation. When in full operation it will be capable of producing from about 500 to 700 tons of coal per diem. The arrangements at the pit head and elsewhere are much the same as those at the Dalhousie pits. The workings of the Forster pit, Dalhousie pit and Crushed mines are pumped from the Engine and Staple pits at the Crushed mines, communication being made for this purpose. The water is lifted by a large double-acting Cornish pumping engine of about 100 horse-power driving the top lift of the pumps in the Staple pit, and the bottom lift in the main or Engine pit, the lifts being about 250 feet each.

Foord pit works.—The Foord pit works, when in full operation, will be of Foord pit works. so great importance to the coal field that I may be excused for giving the full description which follows of the pits and machinery in so far as

complete at the time of my return from field work. In size and in the perfection of design in the machinery, and in fact of the entire plant, these works will compare most favourably with any on this Continent, and may be considered an important addition to the wealth of the Dominion.

Two principal pits.

Two principal pits, known respectively as the Foord drawing and pumping pits, have been sunk to the Main seam at a horizontal distance of 960 yards from the crop, reaching a depth of 878 feet; and a third to a depth of 330 feet for the first or top lift of the pumps, the drawing pit being about 40 yards to the deep of the other two.

Drawing engines.

The drawing engines are two high-pressure horizontal cylinders 36 inches in diameter and 5 feet stroke, or as connected, of about 160 nominal English horse-power. The crank-shaft connecting these engines is 15 inches in diameter and carries a 20-foot drum, included between two 22 feet fly-wheels, which are fitted with powerful friction brakes, by means of which the engines can be stopped almost instantly, should circumstances require. The engines are fitted with slide-valves, moving on anti-friction rollers, and the arrangement of weigh-bars for the throttle, links and brakes is such that one engineer has them under perfect control. The cages in the pits are made of bar steel, weigh about 900 lbs. apiece, and are double decked, carrying four cars or boxes holding 1500 lbs. round coal each. With the moderate piston speed of 250 feet per minute, and allowing full time for all ordinary delays and stoppages, these engines ought easily to deliver 1000 tons of coal on the platform, per day of ten hours, which, with coal from the banks, would make the ordinary production in full operation about 1500 or 1600 tons of coal per diem.

Engine house.

The engine house (61 by 35 feet) and all fittings in the pits and around the pit head are of the most substantial character, the engine house being of cut stone and brick, the foundations of cut stone and concrete, the pillars for the platform of brick, and the timber work of frames, platform and pit-timbering, of the best southern pine, a ship load of which was especially selected for these works.

Pumping engine.

The pumping engine is a single cylinder, high-pressure Cornish engine, the cylinder being 62 inches in diameter and of 9 feet stroke, or 240 nominal English horse-power. This engine is set upon a massive column of cut stone, resting on the solid rock below. The height of this pillar is as follows:—From the foundation (at the surface of the ground) to the top of cylinder pillar 21 feet 6½ inches; thence to the top of the beam pillar 22 feet; and from the top of the beam pillar to the centre of the bearings 4 feet 6 inches; or about 50 feet from the surface of the ground to the bearings.

The cylinder is set over the top-lift pit, the piston-rod, 8 inches in diameter, coming through the cylinder bottom, driving the top set of pumps

direct, as in the Bull engine, the second and third sets being driven through the beam, which is of wrought iron plates riveted to iron castings. This beam is 34 feet long, 7 feet deep in the middle and 2 feet 4 inches at the ends, its weight being 18 tons, without gudgeons, these being of wrought iron 14 inches in diameter for the central one at the bearings, increasing to 16 inches in the middle, the end gudgeons being 8 inches in diameter, increasing to 9½ inches in the middle, and the intermediate for parallel motion rods being 4½ inches in diameter.

The pumps, etc., are of the following patterns and sizes :

Pumps.

First or top set lifting pumps, working-barrel, 18 inches diameter.

Second or middle forcing pumps, working-barrel, 18 inches diameter.

Third or bottom set lifting pumps, working-barrel, 18 inches diameter.

Column pipe, inside diameter, 19 inches.

Both drawing and pumping engines are supplied with steam by a suite of six cylindrical boilers, high pressure, 5½ feet in diameter and 35 feet long, fed with water by two donkey engines and pumps of 7-inch steam cylinder, and fitted with the latest appliances for convenience and safety. Flues, furnaces and stacks, are substantially built and lined with fire-brick. Boilers.

The General Mining Association own a fine railway, six miles long, from the Crushed mines to the loading ground, with branch lines, sidings and passings amounting probably to four miles additional. The loading wharf is situated on Pictou Harbour, at the mouth of the East River, and extends 400 yards from the shore to 22 feet of water. Railway.
Wharf.

Vessels of greater draught than 20 feet are generally loaded with coal from lighters owned by the Company, who also keep a powerful tug in the harbour for the convenience of vessels consigned to them. The arrangements at the wharf and the amount of rolling-stock, including five locomotives, appear to be ample for a shipment of about 8000 tons per diem. The largest amount thus far regularly shipped was during the summer of 1867, when shipments averaged for some weeks 2,400 tons per diem.

The locomotive, car, and blacksmiths' shops are well stocked and arranged, and at the machine shop and foundry all small machinery, and even some slope engines of considerable size, (24 inch cylinder), and of very creditable workmanship have been manufactured. In addition to the works described, the Association have built a large number of houses for overmen, workmen and others, and have a full complement of repair and carpenters' shops, barns and other buildings, all upon the property area of the company. Work shops.

UNDER-GROUND WORKINGS MAIN BEAM.

The first pits at the Albion mines known as the Stair, Store, Engine and Bye pits, gave access to the workings of the Burnt mines, which extended Burnt-mine
pits.

on the lower level about 250 yards southeast, and 900 yards northwest toward the Dalhousie pits, the deepest pit being the Engine or drawing pit, 199 feet to the bottom of the Main seam. These pits are now entirely crushed in and filled with *débris*. Separated from these workings by a barrier of about thirty yards of coal are the Crushed mines, which were worked from the following pits :

Crushed-mines pits.	Engine pit for pumping.....	451	ft.	6	in.	to Main seam.
	Bye or No. 1 pit for drawing.....	436	"	6	"	" " "
	No. 2 pit.....	392	"	0	"	" " "
	No. 3 pit.....	332	"	0	"	" " "
	No. 4 pit.....	284	"	0	"	" " "
	Up-cast pit.....	248	"	0	"	" " "

Pits Nos. 1, 2, 3 and 4 correspond to the four railway bords or main levels, in former times a pit being sunk for every six working bords.

The lowest level of the Crushed mines extends about 1000 yards southeast from the Bye pit, or about 180 yards beyond the meeting of the three roads near the Big branch bridge, East River ; and from this level at 600 yards from the pit a slope was sunk, running eastward at *half across dip*, or at an angle of 10° , and from this slope, workings were in successful operation until the fire occurred which caused the Crushed mines to be abandoned. Westwardly the lower level extends about 1200 yards to the barrier of the Dalhousie pit workings, and at about 100 yards from the pit a slope has been driven about N. 48° W. 700 yards.

Foord pits. Fears have been entertained by the workmen employed in the Foord pits that danger might exist of *holing into* these old workings, now full of water ; but according to careful plans, as kept in the office, no point of these deep workings approaches nearer than about 400 yards, or nearly a quarter of a mile, to the Foord pits.

Dalhousie pits. The Dalhousie pits are four in number : 1, Dalhousie Bye pit 250 feet deep ; 2, Engine pit of the same depth ; 3, Top pit 130 feet deep to the Main seam ; and Dalhousie Down-cast pit 440 feet deep through the Main to the Deep seam.

Dalhousie section of Main seam. The section of the Main seam at the Dalhousie pits is as follows, reduced from the records of the Engine pit :

	<i>Fl. In.</i>
Coarse coal.....	0 2
Good coal.....	4 8
Iron stone.....	0 6
Good coal.....	13 3
Iron stone.....	0 4
Coarse coal, of good quality.....	7 0
Iron stone.....	0 4
Coarse coal.....	2 9
Iron stone.....	0 4

	<i>Ft. In.</i>
Coarse coal.....	2 7
Iron stone.....	0 5
Coarse coal.....	4 5
	<hr/> 36 9

To the east of the Dalhousie pits the upper twelve or fourteen feet only of the seam was worked, the bottom coal not being considered marketable. To the north-west, however, the whole seam is worked in the Dalhousie workings, giving some twenty-eight feet of excellent coal, the bottom being coarser merely in appearance. The six-inch parting of ironstone increases going west and encroaches on the *fall coal*, which is not worked at the Forster pit. Farther west, at the western face of the Forster pit workings, the whole seam appears to deteriorate somewhat, the coal becoming of a dull lustre and shaly texture, and several of the partings increasing in thickness. About twenty-two feet of the lower part of the seam is there worked.

The lower levels of the Dalhousie pit extend 1,100 yards north-west to the Forster pit, dip workings having also been extensively wrought from a slope, the head of which is near the Dalhousie Engine pit, through which steam is supplied to the slope engines. These engines, and also those of the two Crushed mines slopes, are horizontal drawing engines, with connected 24-inch cylinders and 48-inch stroke. They hoisted coal trains of twelve boxes each. The bearings and distances to which this slope was driven are N. 48° W. 920 yards, then, the dip increasing, N. 66° W. 160 yards farther. Lower levels.

From the Forster pit the lower railway bord or main level has been carried 480 yards west, giving an entire length of working of 3,600 yards from the eastern face of the Crushed mines. On account of the deterioration of the seam going west very little coal has yet been taken from the western workings of the lower levels; a slope 150 yards to the dip and a travelling way driven to the crop constitute their extent. Forster pit.

The Foord pit workings under ground consist of the three pits already described and a small amount of narrow work, the levels extending at present about 100 yards north-east and south-west from the pit bottom. The progress of the workings has lately been delayed by an explosion of gas, which, but for previous precautions and promptness of action, might have proved disastrous. Fortunately however, the men were got out without injury, the loss being that of the horses under ground and the burning of a portion of the timbering and guides of pits. The damage having now been repaired, work will be resumed at once. At the time the explosion occurred (March 27th, 1869) eighty four men were employed under ground. Explosion
Foord pit.

GEOLOGICAL SURVEY OF CANADA.

UNDER-GROUND WORKINGS DEEP SEAM.

The Deep seam workings are reached by Cage (drawing) and Success (picking) pits. The capacity of these works is similar to that of the Success pits, and the over-ground works are of the same design and extent, with the exception of the pumping machinery, consisting of a large horizontal engine driving two lifting pumps.

Levels have been driven about 2,800 yards west of the Cage pit, and about one mile of this distance the coal above the bottom level, about 150 yards from the crop, is standing in pillars, with the exception of a section 1500 yards from the pit, where pillar working has been commenced. Eastwardly from the pit the workings have been carried only about 170 yards, where gas becomes so troublesome that work was stopped. The section of the Deep seam, near the eastern face, is nearly as follows:—

	<i>Ft. In.</i>
Dark brown carbonaceous fireclay.....	4 0
Dark brown carbonaceous shale.....	0 6
Good coal.....	2 9
Coarse coal.....	0 9
Good coal.....	2 9
Coarse coal.....	1 4
Good coal.....	5 0
Shale or shaly coal, not exposed.....	3 0
	<hr/>
	20 1

Going westward the character of the coal materially improves. At three quarters of a mile from the Cage pit the section is:

	<i>Ft. In.</i>
Good coal.....	6 6
Very coarse coal holding much iron pyrites, called stone parting.....	1 6
Good coal.....	11 9
	<hr/>
	19 9

Here the seam is at its best, and was all worked, yielding, with the exception of the coarse coal parting, most excellent coal. From the fourth quarterbalance to the western face, the bottom bench, ten feet of good coal was worked; the upper portion of the seam has not been proved lately.

SYSTEMS OF WORKING AT THE ALBION MINES.

With slight modifications the *post and stall*, or *pillar and bord* system of working has been used in the Albion mines since the first openings were made. The practice of this system involves long bords, or working places, with gate roads or inclines, running diagonally across the bords to the main level, at such an angle to the full dip, that the coal can be easily taken to

the railway bord by sleds drawn upon the floor of the seam; by cars running on railway tracks, drawn up to the bords by horses, and withheld from too great a velocity in descending by a drag chain running around a stout post at the head of the incline; or by cars running on a three-rail track, with passings, a drum with a friction brake being so arranged at the head of the incline that the loaded cars in descending draw up the empty ones. The bords are in most cases about 6 yards wide, the pillars from 8 to 12 yards.

During the past two years the new back-balance or self-acting counter-balance system has been introduced at these mines, and is now in successful operation in the Cage-pit workings. This was first used in Lancashire, England, and was introduced into this province by Mr. Hudson of the General Mining Association. Back-balance.

In this system an incline about 10 feet wide is started from the main level, and driven direct to the rise, either to the next level, or above the upper level, as far as it is intended to work the coal. Two tracks are laid in the back-balance, extending from the the main level to within about 20 feet of the top of the incline, where a drum fitted with a friction-brake is firmly set. Upon one of the tracks (say the left for illustration) runs a car or box so loaded with stone as to rather more than counterbalance the weight of a cage running on the right track when loaded with the weight of an empty ear (supposing them to be connected by a wire rope or chain, passing round the drum at the head of the incline) while the weight of a full car on the cage will cause it to descend, raising the weight of the car loaded with stone.

In getting the coal a barrier is left for the main level, and then the first working bord is turned from the back-balance (to the right) and continued on the strike toward the next counterbalance, a distance varying from 150 to 200 yards. Farther to the rise working bords are turned off at regular intervals, the system in the Cage-pit working being, main barrier 21 feet, bords 18 feet, pillars 18 feet. The platform of the back-balance cage runs down to a level with the floor of the main level, and a section of track is laid upon it (as in a pit cage) which is continuous (when the cage is in position), with the rise track of the level. An empty car now being run on to this cage, and the brake of the drum being slackened, it is evident that the car will be drawn up the incline by the counterbalance weight, and that it can be stopped by the brake opposite to any of the bords where it may be required.

A temporary track being kept to the working face of all the bords, the car is run into the bord, filled, and again run into the cage, when its increased weight causes it to descend, the speed being regulated by the brake. On its arrival at the main level, it is pushed from the cage by an empty car, which

Economy of the system. in its turn goes through the same process. As an example of the expedition and economy of this system, I may mention that one boy, at \$0.60, can at the Albion mines brake down from 275 to 300 boxes of coal, holding 1500 lbs. of coal each, per day of ten hours.

Fire damp. In the working of both the Main and Deep seams fire-damp or light carburetted hydrogen gas is sometimes given off the coal, in quantities which not only prove troublesome in requiring safety-lamps and other precautions, but also sometimes cause explosions disastrous to life and property, in spite of all precautionary measures. Several serious explosions have occurred in the older workings, in which not only have men been seriously injured, but the coal in the seams has been ignited, threatening the entire workings with destruction. In fact, so alarming did one fire from this cause become that it was deemed necessary to turn the water from the East River into the workings (the present Crushed mines) as the only possible means of extinguishing the flames. The greatest care is taken to prevent these disasters, to which all the mines of this region are liable, stringent rules being provided with regard to the use of the lamps; and by order of the Inspector of Mines, danger signals are posted, beyond which open lamps cannot be taken.

Precautions at the Albion mines.

At the Albion mines the greatest precaution is observed; barrels of water being kept in every working bord, and several small cannon are kept constantly loaded when gas is feared, to extinguish it if possible by concussion of the air. With all this care a blower of gas will sometimes ignite, generally from a blast, and become troublesome. Into the crack from which one of these blowers appeared, an inch copper tube was driven, and the gas ignited, when a flame was produced two feet long, which burnt continuously for six weeks. Against these explosions the only safeguards appear to be the most perfect ventilation, and cutting instead of blasting the coal.

Difficulties of working great seams.

The working of seams of coal of the size of the Main and Deep is at best a very difficult problem, requiring great care and experience. The explosions, fires and inundations to which the greater portion of the Crushed-mines workings have been subjected have proved the immediate causes of the *crushes* extending over these workings, and also over a portion of the workings of the Dalhousie pits, resulting in the loss of several of the Crushed-mines pits, and a large amount of pillar coal. The original cause of these crushes, however, has been from an inadequate scale of pillarage, the large size and considerable angle of the seams requiring pillars of an extent proportionally much greater than those required in most of the English coal fields, where, as a rule, the seams are of moderate size and the angle of dip quite low.

Inadequate pillarage.

Faults.

Very few faults have been struck in the workings of the Albion mines. Three were met in the Crushed mines dip-workings of the east slope. The

first has a course of N. 21° W, being a downthrow east of 40 feet at the dip slopes and running out to 3 feet at the lower level of Engine pit. The second is still farther, being at the end of the slope ; its course is N. 10° W. ; it is a downthrow eastward of 14 feet. The third is one connecting the first and second and not cutting the first ; its course is S. 73° E. ; it is a downthrow to the northeast of about 50 feet, where proved at about half distance between the first and second faults. Near these faults the gas Gas near faults. was struck which caused the fire in the Crushed mines. Besides these three a few small faults are found in the workings of both seams, which appear to be arranged in two systems, the one running N. 33° W., the other S. 88° E., which, it will be observed, are the courses of several of the important dislocations affecting the general distribution in the coal field.

The parallelism of the cleats or joints of the coal, and also of numerous Cleats. small faults of a few inches throw, in the Deep seam, is quite noticeable though by no means exceptional. With very few exceptions their course is N. 58° W., while in the Main seam no marked parallelism is observed, some running N. 67° E., others S. 88° E., N. 33° W. and N. 58° W.

ACADIA COAL COMPANY OF NEW YORK, U. S.

The Acadia Coal Company own three mining rights, which are as follows : Acadia Coal Company.

The Fraser area, south of the General Mining Association's area ; the Carmichael area, southwest of the General Mining Association's area ; and No. 3 area, lying to the south of the Fraser area.

FRASER AREA.

Workings have been carried on for many years upon the Fraser area ; Fraser area. first by the General Mining Association, and more lately by Mr. J. D. B. Fraser, of Pictou, from whose possession it passed by lease to the present company.

Attempts have been made by former owners to work the Deep seam on the western portion of the area at the McKenzie pit, and a slope has also been driven some distance on the crop of the Third coal seam, both of which workings are now abandoned, and therefore require no special description. McKenzie pit. Deep and Third seams. The present workings are confined to the McGregor seam and two openings on the Oil-coal.

MCGREGOR COLLIERY.

In the McGregor colliery the openings consist of No. 1, an adit, No 2, a slope, and No. 3 a pair of slopes. McGregor colliery.

Adit No. 1 was opened by the General Mining Association on the left bank of Coal Brook, near the crossing of the Middle River road, and driven No. 1 Adit.

N. W. a distance of about 800 yards. The seam was irregularly worked by the General Mining Association and Mr. Fraser, but is, I believe, for the present abandoned.

No. 2 slope.

Slope No. 2 is a single slope to the lower level of No. 3 slopes, and was formerly the working slope, but is now used only as a travelling way. It stands on the left bank of Coal Brook near the mouth of No. 1. Slopes No. 3 are the principal working. Their situation is 170 yards S. E. of No. 2, on the right bank of the brook. Their total depth is 510 feet. Main levels extend 260 yards N. W. and but 20 yards in the contrary direction. The dimensions of the slopes are : Drawing slope (a double railway track) 9 feet post, 9 feet cap and 14 feet ground sill. The tracks are all of T iron 25 lbs. to the yard. The second slope, a travelling way for horses and men, is separated from the drawing slope by a 14 feet barrier of coal ; its height is the same as that of the drawing slope, with 6 feet cap and 8 feet ground sill. A temporary engine is of 14 nominal English horse-power, with a horizontal single cylinder, driving the hoisting drum by shafting with clutch gearing ; and also pumping through the Fleming pump pit by a wire rope running over sheave pullies to the pump bob.

No. 3 slopes.

In working the McGregor seam the upper coal (included in the upper six feet of the seam) is the only portion taken out, the lower bench being unsaleable. The seam is found to rapidly improve going west, as will be seen from the following sections :

Upper coal.

McGregor seam, upper coal.

	At No. 2 slope.	At western face.
	<i>Ft. In.</i>	<i>Ft. In.</i>
Good coal.....	1 9	2 9
Arenaceous fire-clay parting.....	1 0	0 6
Good coal.....	3 0	4 0
	<hr/> 5 9	<hr/> 7 3

Near the western face, the bord and pillar system with incline gate roads has been commenced. Elsewhere in the working the back-balance system is used.

OIL-COAL WORKINGS.

Oil-coal.

Two slopes have been sunk upon the Oil-coal seam, namely the Fraser mine on Coal Brook, near No. 3 slopes, and the Stellar mine on McCulloch's Brook. The principal value of this seam consists in the large quantity of oil contained in the bench mentioned as oil-coal in the general section, which in former years was extensively worked, the oil coal or *stellarite*, as it has been named by Professor Henry How, who first described it, selling for a high price for gas-making and distillation. The present low price of coal-oil from the extensive working of petroleum in this country and the United States, combined with the high tariff on imported

coal imposed by the United States, have combined to render the working of this seam unprofitable, and both workings are for the present abandoned.

As the quality of this peculiar coal will receive especial attention in the Appendix to this report, I will merely state in conclusion that from the large content of oil this seam must at some time prove of considerable value. From pits sunk by the Acadia Coal Company it would appear that the size and quality of the Oil-coal bench improves towards the east, the greatest thickness (1 foot 10 inches) being procured in a pit sunk at the corner of Grove street and Pennsylvania avenue in Acadia village, which coal produced 120 gallons of crude oil to the ton; the average obtained from the Fraser mine being about from 60 to 65 gallons per ton.

CARMICHAEL AREA.

For many years no workable coal was known to exist to the west of the McCulloch-brook fault, on which the Albion coal seams are lost; and though many attempts were made to ascertain the position of these seams no coal was found until the 18th April, 1865, when Mr. Truman French, in prospecting for the Nova Scotia Coal Company, discovered the fine seam of coal now known as the Acadia seam, and presumed to be equivalent to the Main seam of the Albion mines. The first opening of this seam was on the area under consideration, near its western boundary, from which point it was traced north and south, as described in treating the general distribution of the coal seams.

ACADIA COLLIERY.

The Acadia colliery, locally known as the Acadia west slope, is situated near the south-western corner of the Carmichael area, and within the village of Westville. Two slopes, corresponding in dimensions to the No. 3 McGregor slopes, have been sunk on the Acadia seam to a depth of about 140 yards from the crop.

The section of this seam and the strata immediately overlying, as measured in the air shaft of this colliery, is as follows:

		<i>Ft. In.</i>	
Brown carbonaceous shale.....		4 6	
Black bituminous oil shale.....		0 7	
Brown carbonaceous shale.....		6 6	
	<i>Ft. In.</i>		
Good coal, (1st bench).....	} Fall coal	2 9	
Good coal, (2nd bench).....		3 6	
Light arenaceous fireclay or holing.....		0 3	
Good coal, (3rd bench).....	} Bench coal	3 8	
Coarse hard coal with iron pyrites, easily separated by dressing from the other coals.....		0 1	
Good coal, (4th bench).....		3 3	
Coarse coal of fair quality.....		2 4	
Coarse coal not taken out.....		2 4	
		<hr/>	
		18 2	
		<hr/>	
		29 9	

Black shales

Above the section given, no details for a column of strata can be procured, no record having been preserved of the numerous pits in the overlying measures. The remains from these pits, however, will enable me to state that at this colliery the seam is overlaid with a great mass of barren measures, consisting of black and brown carbonaceous and argillaceous shales, with occasional bands of dark arenaceous shale, and at least two thin bands of thinly laminated sandstones of a general white colour with black partings, as in the sandstones described in the Forster pit section. Under the seam there is a yellowish-drab *Stigmaria* underclay of at least four feet in thickness. The measures are then concealed for forty-two feet, at which point a heavy bedded sandstone appears, of a light brownish-drab colour, containing, where exposed in a quarry near the Acadia slope, large *Stigmaria* roots well preserved, as well as occasional stems of *Lepidodendron*.

No faults.

At this colliery the seam has been proved to be without fault, by the main level, which now extends about 500 yards south and 400 yards north, the exact direction across the area being N. 41° W., (or N. 18° W. magnetic) corresponding to the dip of the seam, N. 49° E. (or N. 72° E. magnetic), which varies only in inclination, being 19° at the surface and about 23° at the lowest level. The under-ground workings are on the counter-balance system, and are remarkably regular and well laid out. Counter-balances are driven 15 feet wide and 100 yards apart, throughout the workings. An air course 8 feet wide is also driven up at 10 yards to the left of each counterbalance. Working bords are 15 feet in width, with 15 feet of pillar, 75 feet of barrier being left above the main level.

Counter-balance system.

MACHINERY.

Machinery.

The platforms at the head of the slope are roofed in. They extend from the mouth of the slope to the banks, and also to the shutes over the railway track. At this mine the fine slack is not sold, being carefully screened out, the rest of the coal being divided into two sizes, *round* and *chestnut*. The drawing engines were built in New York, and are fair specimens of the best type of American engines, being compact and easily handled, with none of the slightness of design usually observable in American machinery. They are horizontal high-pressure connected engines, 16 by 48 inch cylinders, working by a 24-inch pinion into a 16-foot spur-wheel on a 14-foot drum. The engine house is of brick and cut stone, with a corrugated iron roof. Pumping is effected by a small donkey engine, which is also arranged to hoist bank coal to the screening platform, the quantity of water in this mine being so insignificant that a two-inch column-pipe is sufficient to deliver it.

Drawing engines.

SECOND SEAM.

the Acadia seam was followed by the discovery of a *Second seam*, lying at about 160 feet, by Capt. Blacker of the t the pit sunk by him the following thickness was

	FT.	IN.
.....	3	10
.....	7	8
	<hr/>	<hr/>
	11	6

as *good coal* seems, from the specimens I have seen, racter, and none that has come before me would be Jarmichael area this is opened by only one trial-pit,

AREA NO. 3.

Acadia area no coal has been found, but from the *Area No. 3* by trial-pits, of the black shales overlying the Main that the representatives of this and underlying seams tion of this area to the west of the McCulloch-brook r character of the coal no information can be obtained specting. The only opening which is near this area d from the strike of the Culton seam at that point, that it will continue on to No. 3 area.

RAILWAY.

Company have built a fine single-track railway of *Railway*. alf miles in length, the main line extending from the ack of the government railway at a point near Coal assing through the Acadia village near the McGregor it is connected by sidings. From the junction at the oal is conveyed over the government railway to the nd at Fisher's Grant, on the east side of Pictou har- *Loading ground.* nce. The shipping wharf extends into the harbour 850 ster at low tide. It is a well built structure, 20 feet es at both sides and end, empty trains being made

BUILDINGS.

ses have been provided for miners and labourers at the *Buildings.* ch is very tastefully laid out in regular streets and being very substantially built, and of a much better to provide for like purposes. plant at both slopes, including the blacksmith and e building and overmen's houses, is very complete.

INTERCOLONIAL COAL MINING COMPANY OF MONTREAL.

Intercolonial
Coal Company.

Two mining areas are owned by this company, the Bear Creek area to the south of the Carmichael area of the Acadia Coal Company, and the Sutherland area, which lies to the north of the area of the General Mining Association.

BEAR CREEK AREA.

Bear creek area.

The Acadia seam was opened upon this area soon after its discovery in 1865, at a point known as Campbell's pit, near the north line of the area, and from this pit, as worked by the then owners of the area, and subsequently by the agents of this company, a considerable amount of coal was taken for consumption in the immediate neighbourhood. After a careful survey by Mr. William Barnes of Halifax, a competent mining engineer, (which survey will again be alluded to) the company decided upon the location of the present colliery.

DRUMMOND COLLIERY.

Drummond
colliery.

The erection of buildings and machinery at this colliery and the first work at the present slopes was commenced about November, 1867, since which time works of considerable importance have been erected, a railway has been built, and a large amount of coal (about 70,000 tons) has been shipped.

The section of the Acadia seam at this point is as follows, the measurement being taken in the air shaft of the colliery :

	Ft. In.
Good coal with a smooth parting two feet nine inches from the bottom, (full coal).....	5 9
Light gray soft fireclay; it varies slightly in thickness; (holing).....	0 3
Good coal, top bench.....	5 6
Gray hard coal, giving a pink ash. }	0 6
Good coal, second bench.....	4 6
Coarse coal, not worked.....	2 1
	18 7

UNDER-GROUND WORKINGS.

Under-ground
workings.

The present workings consist of two working slopes driven about 900 feet from the crop of the seam, the dip being about 16° at the surface, decreasing to 14° at the lower level, at 730 feet from the surface. The size of these slopes is 9 by 9 feet, with a central barrier of coal between them of 28 feet, each slope having a single track and travelling-way. Main levels for two lifts have been driven from the slopes *north* and *south* upon the seam, the north levels being worked from No. 1 slope and the south from No. 2; thus far I believe the lower levels have been most extensively worked, a considerable amount of coal being left

near the crop for safety. I have not had an opportunity of examining a detailed plan of the workings, but my inspection of them would lead me to believe that the system of pillarage is planned with more than usual regard for safety. Both the post and stall and counterbalance systems of *getting* the coal were at first tried with a view of ascertaining their comparative economy, and I believe that Mr. Dunn has selected the counterbalance system for the future working of the mine.

But little water has as yet been met with, and it is at present raised by water cars, no pump having been found necessary.

OVER-GROUND WORKS.

The arrangements at the surface seem exceptionally well planned and have given great satisfaction. At the head of the slopes a large heapstead or covered screening platform is erected for the separation of different sizes and qualities of coal, and for banking out. The coal boxes are drawn on to this platform in trams of from five to twelve (holding from 500 to 600 pounds each) and thence delivered by dumps on to the screens, where the coal is separated, as at the Acadia colliery, into three sizes: round coal, nut coal and slack. The platform extends over eight railway tracks, four for each slope; its floor is level with the top of the bank, for banking out, and in shipping bank-coal a railway track is run along the foot of the bank, and from this level the bank cars are raised to the main platform in a cage lifted by a small donkey engine, which is also arranged to drive a circular saw for the car shop of the colliery. Over-ground works.

The drawing engines are horizontal connected engines of about 50 nominal English horse-power; they are of Scotch manufacture, and are fitted with an extremely ingenious arrangement of friction gearing, by means of which the two slopes may be worked independently, by one engine, a matter of great convenience. Engines.

RAILWAY.

The railway of this company extends from the Drummond colliery to their shipping wharf at Granton on the Middle River, near Abercrombie Point, the position of which will be seen on the map. The main line of single-track railway is laid with 56-pound rails, with the new steel scabbard joint, which has proved so successful on the Pictou and Truro branch of the Nova Scotia railway. This railway was built in 1868 by Mr. Joseph B. Moore, contractor, in the most complete manner, the track being well ballasted with broken sandstone and a coarse conglomerate from the cuttings near Waters's Brook, the culverts of cut stone, and the bridge of trestlework with cut stone foundations. Railway.

The rolling stock of this railway consists of three locomotives, miscellaneous platform and construction cars, and sixty new coal waggons carry- Rolling stock.

ing from six to seven tons of round coal each, twenty of which were built at the Drummond colliery car shop. In connection with the railway are provided at the colliery, car shops, locomotive-sheds and weigh-houses. The length of the main line of railway from the colliery to the wharf is about seven and one quarter miles, which, with sidings, turn-outs and standing tracks at the colliery, will probably raise the total length of single track to about ten miles.

Shipping wharf.

The shipping wharf of the Intercolonial Coal Company is a fine structure of wood upon stone and crib-work piers, extending in a curve into the channel of the Middle River to about 22 feet of water. The arrangement at the platform of the wharf is such that there is a slight incline of one track downward from the shore to the end of the wharf, and thence a further down grade on a second track back to the shore, the design being that as fast as coal is required at the shipping places or *shutes*, the full cars are allowed to run by their own gravity to the point required, whence, on being emptied, they will again return by their own weight to the shore, to be made up into *empty* trains. They are switched back at the end of the wharf on to the *empty* or inside track, running parallel to the *full* track, upon which they are pushed by the locomotive in coming from the colliery. This arrangement has, I believe, given great satisfaction, as it results in a saving of the horses usually necessary for handling coal cars at the shipping wharves.

The railway and wharf were opened for traffic about the 1st of October, 1868, and before the close of navigation several thousand tons of coal were shipped. During the present season the colliery has been in successful operation, and a considerable quantity of the coal has found a market in the provinces of Ontario and Quebec.

West fault.

In the description of the general distribution of the coal in the Bear Creek synclinal it has been stated that at a few hundred yards to the south of the Drummond Colliery the crop of the Acadia seam comes against the West fault. The fact that the crop of the seam was here lost upon a fault "with a S. W. upthrow and a bearing of N. 10° W." magnetic, (or N. 33° W. astronomical) was proved and stated by Mr. Barnes. A few yards to the west of the spot where the coal of the Acadia seam was lost another seam of inferior coal, about three feet in thickness, was found, and beyond it, to the south-west, a second fault with a south-west upthrow was observed, bringing up red and gray sandstones. These sandstones I have examined and believe to belong to the Millstone Grit series.

The first fault mentioned appears to coincide in position and bearing with the general run of the West fault, and, as it will certainly be the western boundary of the workable coal, I have in the map shown it as that fault, but it is quite possible that here the great West dislocation may turn

patch of the lower portion of the coal measures first fault, its throw being completed by the Barnes, bringing up the Millstone Grit.

The Acadia seam removed by this fault, as at is unimportant. This is known from the fact the seam have been traced along the east side at very low angles it is probable that only some of the crop will be cut off by the fault. No why the second levels from the Drummond and regularly to the south-eastern portion of

SUTHERLAND AREA.

done upon this area, and no coal has as yet been found in that the North fault runs diagonally through the area. To the south of this fault the area is of the lower seams or a portion of them. The and any seams which may be found above it, turn to a westerly dip upon this area, and at a point where their crops will come against the fault. It, perhaps, be successfully worked in connection with the Sutherland area, and a small portion of the northern Nova Scotia Coal company. Sutherland area.

ANY OF NEW HAVEN, CONNECTICUT, U. S.

mining right of three and one-half square miles in the Nova Scotia Coal company. Nova Scotia Coal company.

FRENCH AREA.

extends to the north and west of the Carmichael French area. company. The workings consist of a slope upon 6 feet from the crop, from which a few irregularly opened and several hundred tons of coal are now being worked. The dip here is 28° at surface, increasing to 35° at a section of the Acadia seam was measured. The dip is as follows, the measurements being taken at right angles to the plane of the seam:

ACADIA SEAM.		Section of Acadia seam.	
Thickness and quality being on the authority of		Ft. In.	
of the Nova Scotia Coal Company.....		2	6
.....		4	8

	<i>Ft. In.</i>
Dark brown arenaceous fireclay, compact and hard ; the thickness varies, the average being.....	0 10
Good coal, finely laminated.....	2 9
Shaly coal and dark brown coarse arenaceous fireclay in thin beds, known as <i>stone parting</i>	0 9
Good coal, locally known as the <i>middle bench</i>	2 3
Dark brown arenaceous fireclay.....	0 0½
Coarse good coal, giving a reddish ash.....	1 0
Dark brown soft fireclay parting.....	0 0½
Good coal with a coarse and somewhat <i>twisted</i> structure ; the good quality of the coal is given on the authority of Mr. French.....	2 4
	<hr/> 17 2

SECOND SEAM.

Second seam. The section of the second seam at the pit a short distance west of the Nova Scotia slope, is stated by Mr. French to be as follows :

	<i>Ft. In.</i>
Shale and coal.....	3 0
Good coal.....	9 0
	<hr/> 12 0

NOVA SCOTIA COLLIERY.

Nova Scotia Colliery.

Railway and wharf.

West fault.

Until the present season the opening on the Acadia seam has lain idle, but the erection of works is now in progress, and it is hoped that the colliery will be in active operation by the opening of the season of 1870. A survey has been made and ground broken for a railway, and a wharf is being built near the Intercolonial Coal Company's shipping wharf on the Middle River. It is designed that the colliery shall be capable of shipping some 600 or 700 tons of coal per day.

The exact position of the spot where the crop of the Acadia seam will be lost upon the West fault, upon this area is still an uncertainty. The seam has already been found 396 yards to the north-west of the working slope, and could probably be traced a short distance farther. As the angle between the strike of the seam and the bearing of the fault is very small, the dislocation will encroach but little on the *deep coal* at this mine, for a considerable distance from the slope. In this connection may be mentioned an adit on the right bank of McLeod's Brook near its junction with the Middle River, locally known as French's Tunnel. This was driven for some distance eastwardly upon a bed of several feet in thickness of black shale and shaly coal, which, at one time, was imagined to represent the Acadia seam. This bed is however situated to the west of the West fault, and it would appear to belong to the Millstone Grit. As it is supported by a *Stigmaria* underclay it may, in spite of its impurity, be considered a true coal seam, but is not likely ever to prove of any value.

MONTREAL AND PICTOU COAL COMPANY OF HALIFAX, NOVA SCOTIA.

The Montreal and Pictou area is situate to the north of that of the General Mining Association, to the west of the Sutherland area of the Intercolonial Company, and is bounded on the east by the east bank of the East River. The northern limit of the Productive coal measures upon this area is the line of the great North fault. As yet no regular works have been commenced, though the company have been at considerable expense in sinking a pit upon what has been known as the Montreal and Pictou, or Haliburton seam. From verbal information given me by Mr. Haliburton, Managing Director of the company, and a journal of progress kept by Mr. William Brain, former agent of the company, the following facts with regard to this pit are submitted.

According to Mr. Brain's record, the following strata were intersected in sinking; the thickness being given *vertically to horizon*, the dip being S. 43° E. (or S. 20° E. mag.) < 65°. The descriptions of strata are based upon a personal examination of the pit *débris* :

	<i>Ft. In.</i>
Bluish-gray argillaceous shale.....	13 0
Compact light-gray sandstone.....	0 10
Black argillaceous shale and fireclay interstratified with one another.....	10 0
Coal (bench a).....	10 6
Black carbonaceous fireclay.....	10 6
Sandstone, the colour not given.....	8 0
Fireclay with arenaceous bands.....	3 0
Black carbonaceous shale.....	3 0
Coal (bench b).....	9 0
Coarse coal and shale (bench c).....	2 0
	<hr/>
	64 10

At a depth of 100 feet from the surface, a cross-cut or *stone drift* was driven on the underlying measures, intersecting the following strata, the measurements being taken on a horizontal line :

	<i>Ft. In.</i>
Fireclay.....	9 0
Coal (bench d).....	2 6
Fireclay.....	9 0
Coal (bench e).....	15 0
	<hr/>
	35 6

According to the record these strata must have been in the disturbed measures of a fault, as the section of the shaft shows angles varying from 30° to 85° of overturn or northerly dip. From the level at 100 feet, the shaft was sunk to a depth of 177 feet, without getting the benches of coal

d and *e*, and in the bottom of the shaft a bore-hole was put down 27½ feet further, passing through sandstones, shales and fireclays only. At a depth of 163 feet from the surface a cross-cut was then driven from the shaft to bench *a*, passing through bench *b*, which was only five feet in thickness. With regard to work done in this bench, the following information was obtained from Mr. Haliburton; the workings, being full of water at the time of my visit, could not be examined.

Level. "The upper bench (*a*) where cut by the stone drift from the pit was ten feet six inches in thickness, yielding three and a-half feet of workable coal; upon this bench a level was driven seventy yards south-west. The thickness was at one time reduced to two and a-half feet, after which it increased to twenty-five feet, yielding fourteen and a-half feet of workable coal, the size increasing and quality improving going westward."

Cross-cut and bore-hole. "At sixty yards west of the pit a stone drift was driven across the dip through the underlying measures eighty-four feet, and a bore driven thirty-four feet farther without meeting any of the lower benches (*b*, *c*, *d*, *e*) of coal. The strike at the western face was due west (or S. 67° W. astronomical) and turning rapidly toward the north-west."

Fireclay. In driving the western drift twelve feet of dark brown carbonaceous fireclay were intersected, of which some 300 tons were taken out and sold to the Crown Brick and Pottery Company, of New Glasgow, at \$0.75 per ton, and I am told proved of very good quality. Eastward from the Montreal and Pictou pit the upper bench (*a*) was found to rapidly thin and deteriorate, and work in that direction was soon stopped.

In explanation of the facts just given it can only be said that it is probable an east and west dislocation runs quite near the Montreal and Pictou pit, bringing the lower benches (*b*, *c*, *d*, *e*) into the position in which they were found, the exact direction and dowthrow of which have not been properly observed while the workings were in progress.

Oil-coal. A small seam has been proved upon this area upon the old road to Fraser Ogg's quarry, the thickness of which is given by the Montreal and Pictou Company's record as eighteen inches. The coal from this pit resembles the Stellar oil-coal from the Fraser mine of the Acadia Coal Company, and burns in much the same way, igniting with ease and throwing off small sparks or jets of flame; and it is possible that it is the representative of the Stellar seam on the north rise of the Albion trough. Its stratigraphical distance from the Montreal and Pictou seam appears to be about 200 feet, but with the possibility of intervening dislocations this may be far from correct.

I have already alluded to the possibility of coal beds being found overlying the Montreal and Pictou seam, and to several unproved crops which

losed Oil-coal ; one, probably represent
the old quarry road, near the brick-ya
Pictou pit.

HALIBURTON'S CULTON AREA.

the west of the East River, either who
workable coal seams, there remains to
ea, lying to the south of the Intercolon
A.

en described. This opening, with a bo
xistence of a seam of six feet in thickne
on the northern portion of the area. T
s already been alluded to, and if, as in
quivalent of the Main or Acadia sea
ms of Section 4 should underlie a sm

portion of the area probably bounded by the West, the South, and the
McCulloch-brook faults ; but as no openings exist upon any such sea
o statements can be given of their size or quality.

In conclusion I would state that an Appendix to this Report is in course
reparation, in which descriptions and analyses of the different coals of the
region will be given, together with the results of such practical trials
their economic value as steam and gas producers as I have been enabled
to make ; together with a collation of many facts and analyses already pu
lished which could not be conveniently introduced into the body of the
Report. In the Appendix will also be noticed several deposits of iron ore
in Pictou county, which have received examination during the past two
seasons, with assays and analyses of the specimens obtained from them.

I have the honour to be,

Sir,

Your most obedient servant,

EDWARD HARTLEY.

REPORT

OF

MR. ROBERT BELL, F.G.S.,

ADDRESSED TO

SIR WILLIAM E. LOGAN, F.R.S., F.G.S.,

DIRECTOR OF THE GEOLOGICAL SURVEY,

KINGSTON, April 20, 1867.

SIR,—I beg leave to report that in pursuance of your instructions I proceeded in the month of June last to make a geological examination of Cockburn, Drummond and St. Joseph's Islands, as well as some additional surveys on the western portion of Grand Manitoulin Island, in continuation of the work of the previous season. Mr. Murray having ascertained the main geological features of these islands, it was only necessary for me to trace the boundaries of the formations in more detail. I was assisted in these explorations by Messrs. W. W. Kirkpatrick, John Cadenhead, J. G. Francis and Dr. John Bell. The last named gentleman also made a botanical *reconnaissance* of the islands, and a list of the plants collected and observed by him is given in the Appendix.

TOPOGRAPHY, SOIL AND TIMBER.

The principal addition made to our knowledge of the topography of Grand Manitoulin Island consisted in determining the position, form and dimensions of Lake Mudjee-manitou, a shallow sheet of water about five miles long, with deep bays, lying between Lake Kagawong, which was surveyed last year, and Gore Bay. It was proved beyond a doubt that this lake empties into Lake Kagawong. The outlet, whose course I traced all the way, is a brook sufficiently large to be navigated by canoes, except in

Lakes of Grand
Manitoulin.

low water. Having also fixed with more accuracy the position of the Niagara escarpment from Lake Kagawong to Lake Wolsey, another prominent feature is added to the map of the island. The best soil in this, as in other parts of Grand Manitoulin, is found along the out-crop of the red marl band.

Cockburn
Island.

The interior of Cockburn Island was carefully explored. The surface in this island is generally rolling. In the centre, which appeared to be the most elevated part of the island, the higher ground consisted of yellow sand, supporting a growth of sugar-maple, beech, red oak, and other hard woods. The sand appeared to be underlaid by boulder drift, and was deeply cut by the channels of brooks. The limestone rock was exposed only in some places. The lower levels, forming a considerable portion of the whole area, were occupied with tangled cedar swamps, very difficult to penetrate. Here and there we met with a shallow lily-pond, surrounded with open peaty meadows, but upon the whole, the island cannot be said to be well watered. On approaching the shore from the interior, ridges and terraces of sand and shingle were found at different levels all round the island. Unlike Grand Manitoulin, the woods have not been seriously injured by sweeping fires.

Drummond
Island.

Drummond Island lies lower than any of the other islands of the Manitoulin group. It is almost useless for agricultural purposes, the surface being nearly altogether rock and swamp. A number of ponds are found in the southern part and one brook in the northern. On the north-east side the water is deep and free from obstacles, but on the north-western and southern sides it is shallow and much interrupted by reefs and small islands.

St. Joseph's
Island.

St. Joseph's Island is remarkable for the immense accumulation of drift which is piled upon it, obscuring the underlying rocks. In some places it rises to upwards of 300 feet above the level of Lake Huron. The island is nearly all well wooded, chiefly with hard maple, but the soil is light and stoney. Unlike the other islands, very few ponds occur upon it, and numerous small brooks run down into the lake on all sides.

GEOLOGICAL STRUCTURE.

w anticlinals

In my Report of last year it was shewn that a series of low anticlinals traverses the Grand Manitoulin Island from north to south, and that, owing to the action of denuding agencies, these have given rise to the deep bays along the northern side. The channels separating the various islands of the Manitoulin group have been formed in the same way. The uniformity which thus pervades the whole chain may be perceived by an inspection

annels between the different islands being merely deeper running the bays of the Grand Manitoulin. The massive Niagara formation constitute, as it were, the back-bone of the island, Cockburn and Drummond Islands, as well as of the Lake Huron and Georgian Bay, on the one hand, and Lake Huron and the St. Mary's River on the other. The dip of the strata towards the centre of Lake Huron, and the inclination of the strata, being estimated, on an average, at from forty to fifty

1.—In the broader portions of Grand Manitoulin, the Trenton group.

River and Utica formations and the Trenton group are seen in section from beneath the Niagara strata. The Trenton formation is the most northern points of the island, and its continuation is seen in the small islands at about the same distance from the shore as the Huronian rocks forming the north shore of Lake Huron, say westward to St. Joseph's Island, across which it is the state of Michigan at Neebish Island. As stated in the Report of the Geological Survey of Canada, page 196, limestones of this group are found in the north-east extremity of St. Joseph's Island) and in the sandstone of the Chazy formation on Campment d'Ours; in this region being much obscured by drift, no new facts have been discovered.

The Utica formation has not been met with, in place, west of Maple Point (Grand Manitoulin Island) but its position at the summit of the strata is indicated on St. Joseph's Island by loose fragments of the shale.

Formation.—The edge of the plateau formed by the Hudson River formation presents itself in a high bluff all along the north shore of Manitoulin from Maple Point to Julia Bay. Gore Bay, in the middle of the north shore, is a deep notch cut out of the plateau. The strata are the bold escarpments on either side of this bay. The rate of about one in fifty, is here quite perceptible. It is difficult to observe the outcropping edges of the beds in some places. A section, from the water's edge upwards, was not a straight line, but by connecting two exposures lying close together, it is presumed to be almost as correct as if measured on the east side at the entrance to the bay at the level of Lake Huron.

Fl. In.
A grey argillaceous and finely arenaceous shale—bands of red and lighter shades alternating—crumbling and wasting away under the influence of the weather, interstratified with beds of sandstone thick and from two to fifteen feet apart, of fine grained

First escarpment.

	<i>Pt.</i>	<i>In.</i>
grey shaly sandstone and bluish-grey limestone. The limestone bands are composed of comminuted organic remains, principally small corals, but in addition there were observed a small trilobite, a <i>Leptana</i> , an <i>Orthis</i> , and <i>Ambonychia radiata</i> . The sandstone bands hold <i>Modiolopsis modiolaris</i>	81	0
2. Soft fine grained bluish-grey calcareous sandstone and finely arenaceous limestone in beds from one to six inches thick. The surfaces are uneven.....	6	4
3. Measures concealed.....	80	0
4. Mottled drab and grey soft argillaceous and finely arenaceous limestone, (the more calcareous portions being finely crystalline and gray). The beds are from one to six inches thick, in bands of from two to four feet, alternating with others of about the same thickness, of crumbling bluish-drab finely arenaceous shale with nodular calcareous seams. Both the soft and hard bands are unevenly surfaced and of a nodular character. The fossils are <i>Petraia</i> , <i>Stenopora fibrosa</i> , <i>Orthis lynx</i> and a smaller species of <i>Orthis</i> , a large <i>Atrypa</i> , an <i>Avicula</i> , a <i>Strophomena</i> and an <i>Orthoceras</i>	26	8
5. Dark drab-grey soft brittle fine grained arenaceous somewhat crystalline limestone, in beds from one foot three inches to three feet six inches thick. It holds a small silicified <i>Orthis</i>	10	6
6. Greenish and bluish-gray soft finely arenaceous limestone, in beds from one to three feet thick, separated by layers of bluish-grey shale from two to ten inches thick. The limestone holds nodules of white gypsum from two to three inches in diameter.....	27	7
7. Brownish soft unevenly surfaced earthy looking limestone, in beds of about two inches.....	8	8
8. Brownish-drab and grey limestone in uneven beds from four to ten inches thick. Fresh fractures present a mottled drab and gray color, the grey patches having a crystalline and the drab an earthy appearance. The beds contain rusty cavities lined with rhombohedral crystals of calcareous spar. The fossils are <i>Stromatopora concentrica</i> and <i>Favosites Gothlandica</i> . Near the top is a nodular shaly layer holding iron pyrites, which, on decomposing, stains the face of the cliff with red oxide of iron.....	5	3
9. Brownish and drab-grey thin irregularly bedded or shaly limestone holding <i>Stenopora fibrosa</i> , silicified and abundant, together with cavities lined with calc-spar crystals. This band forms the crest of the main escarpment.....	8	0
10. Brownish and purplish-grey uneven surfaced limestone, mostly in thin beds (the thickest being nine inches). Some of them are very dark and bituminous. The mass weathers yellow, and holds abundance of <i>Stenopora fibrosa</i> in a silicified state.....	37	6
	291	6

Second escarpment.

This last mass (10) rises at a short distance back from the main escarpment in a second cliff above it and, gradually approaching, at a point half a mile nearer the head of the bay than the locality at which the previous portion of this section was measured, it joins the main escarpment and is added to its height.

About a hundred yards still further back, and after an interval of concealment of about seventeen feet, a third terrace rises to the height of twenty-eight feet, but appears to gain in elevation as it recedes eastward. It consists of soft brownish and buff-grey thinly bedded bituminous limestone having a conchoidal fracture, and holding small irregular chalky nodules. The fossils, which are mostly silicified, consist of several species of *Strophomena*, *Orthis*, corals, including *Favosites Gothlandica*, and the small cystidean which elsewhere on Manitoulin Island characterizes the Clinton formation. This terrace is considered to form the base of this formation.

Proceeding westward from Cape Robert, on the Grand Manitoulin, the Hudson River formation is next met with along the north side of Drummond Island, where the upper beds, which are, as usual, of a massive calcareous nature, form a strip about seven miles long and two broad. On Sulphur Island the Hudson River shales lie upon the Huronian rock (Geol. Can. page 219). Most of the small islands between Chipewigan Point (the northwest extremity of Drummond Island) and St. Joseph Island come within the strike of this formation. On the latter island it is deeply covered by drift, and no exposure of it has yet been found, but its position is, to a great extent, determined by the summit of the next lower and the base of the next higher formation. The upper beds were however discovered in place, on a small island close to its eastern shore, about two miles and a-half north-east of the old Fort St. Joseph, at the southern point of the island.

Clinton Formation.—The distribution of the Clinton formation on Grand Manitoulin from Lake Kagawong westward to where it leaves the island was, by additional observations, more minutely determined than last year. On Drummond Island this formation occupies a strip rather more than two miles broad. The line marking its base runs westward across the island from Colton Bay to Vermont Harbor*. As on Manitoulin Island, it consists of grey and drab, somewhat argillaceous limestones, mostly thinly bedded. It is characterized here, as elsewhere, by irregular chalky nodules. Very few organic remains, however, were found, and in this respect it would appear to differ from the portion on Manitoulin. At the summit of the formation the stratum of red marl which on Grand Manitoulin, has been taken as representing the iron-ore band, was found in one place a short distance east of Medford Bay. This soft bed probably follows the channel between St. Joseph's and Lime Islands, and the existence of a similar marl further west, at Sucker Creek, is referred to in the Geology of Canada, page 321. The formation may be traced from Drummond to St. Joseph's Island by the fragments of Hudson River

* Most of the bays marked as "harbors" on Mr. Whitney's map of Drummond Island are only boat harbors.

rocks found upon a number of the small islands between the two. Its base appears to skirt the south side of St. Joseph's Island as far as Hay Point, and thence to strike across the St. Mary's River to the opposite point in the state of Michigan.

Niagara forma-
tion.

Niagara Formation.—On Grand Manitoulin the base of the Niagara formation was followed out, by actual measurement, through all its windings from Lake Kagawong to Lake Wolsey, but its position, as thus determined, does not differ perceptibly from that assigned to it from the observations of last year. From Lake Wolsey, westward, this formation holds the shore to the extremity of the island. Leaving the west end of Grand Manitoulin, the lower boundary (being the northern geographically) of the Niagara strata keeps to the north of Cockburn Island, which, after careful examination, was found to lie wholly upon this formation. It next cuts off the northern part of Drummond Island, passes just south of the southern point of St. Joseph's Island and appears to enter the mainland of Michigan near Sucker Creek. Lime Island, on the American side of the international boundary, and a few of the small islands between St. Joseph's and Drummond Islands are situated upon the Niagara rocks.

Cockburn
Island.

Lime Island.

Regarding the Niagara formation on Grand Manitoulin Island, nothing worthy of special mention, besides the facts relating to its distribution already referred to, was observed, in addition to what I had the honor to communicate to you in my Report of last year. It was then stated that the breadth of the formation averaged nine miles, and the dip, to the southward, one in forty-five.

Dolomites.

Cockburn Island has a breadth of nine miles from north to south, and the dip of the strata being the same as the Grand Manitoulin, the thickness of the Niagara formation, of which this island is wholly composed, will here be about 400 feet also. Along the north shore of the island the rocks (which must be near the base of the formation) consist principally of soft buff-colored bituminous dolomites, suitable for building purposes, and holding a species of *Leperditia*. They are characterized by a conchoidal fracture, which, in natural exposures, parallel to the bedding, gives rise to a succession of small depressions resembling plates and saucers in size and form. These rocks were referred to in my last Report as occurring at Mildrum Point, (the north-western extremity of Grand Manitoulin). The same beds have been quarried for a considerable time at Marble Head, (the north-eastern extremity of Drummond Island. Interstratified with these, on the north side of Cockburn Island, in some places there are found slaty and more bituminous bands of a dark color, and in others even-surfaced beds of a bluish-grey color, which, if not too soft, may be found suitable for flagstones. In the harbour at Thompson's Point (the northern extremity of the island) the buff-colored beds, which vary from two to three

Marble Head.
Drummond Isd.

PORT OF MR. ROBERT BELL.

thickness, present a very rough spongy and internally are full of cavities from the remains of *Pentamerus oblongus*. The same beds throughout the whole formation on the Grand Manitoulin. These soft bituminous beds are marked by grey uneven surfaced bituminous and full of small lenticular cavities, marked by the remains of *Pentamerus*. On the south side of the island, the thin beds of bituminous limestone, are seldom seen and shingle; while on the east and west almost continuously along the beach. The thickness of them attaining upwards of six feet. Marked by a saccharoidal texture. In the interior on the northern side, similar beds are common, however seldom seen in the form of shingle. The steepest slope of the island is the most precipitous, the thick beds, in general, contain corals, but, however, occur at the eastern end, about three miles and a-half north of McLeod's Harbour. Fossiliferous. Among them are two or three species of *Huronella*, in a good state of preservation. The corals are by far the most abundant, and are scattered all over. At the western extremity, opposite to this locality, and in a coralline bed again occur, but none of them in a similar position on the west side of the island. No specimens of this fossil were found except along the east shore of Drummond Island, False Detour, and in a like geological examples.

The Niagara formation has nearly the same character on the two islands being quite like one another. The former has in addition two of the localities. At Marble Head, the eastern end, the corals are obtained than at any other place upon the island. They are a soft drab colored bituminous calcareous with conchoidal fracture. The beds varying in thickness are marked by spongy lumps and by cavities of quartz. These beds are followed by a bed of dark grey and reddish-grey bituminous limestone, containing obscure remains of fossils and the limestones, which give the rock a very open and



GEOLOGICAL SURVEY OF CANADA.

ALFRED R. C. SELWYN, DIRECTOR.

REPORT OF PROGRESS

FROM

1866 to 1869.

ACCOMPANIED BY

GEOLOGICAL AND TOPOGRAPHICAL MAPS.



DAWSON BROS. : MONTREAL.
B. WESTERMANN & CO. : NEW YORK.
SAMPSON, LOW, SON & MARSTON : LONDON.
F. A. BROCKHAUS : LEIPSIC.
BALLIÈRE : PARIS.
1870.

J. D. WHITNEY.

HARVARD UNIVERSITY.

WHITNEY LIBRARY,
MUSEUM OF COMPARATIVE ZOOLOGY.



- Structure above the Chaudière.** In the Geological Report of 1863-66, p. 29, in describing the structure of the country above the Chaudière, the following statement occurs ; "The previous work of the Survey had demonstrated the general structure of the region, and had shown that between the great overlap fault which is the limit of the Quebec group on the northwest, and the overlying unconformable Upper Silurian rocks on the southeast, two main anticlinal axes, affecting its distribution, were traceable from the state of Vermont to the Chaudière River, and beyond. The more northwestern one of these runs from the mouth of the Boyer River on the St. Lawrence, through Stanbridge, and the more southeastern from St. Mary's on the Chaudière by Danville and Melbourne, through Potton, a subsidiary anticlinal branching from it at Melbourne, and running through the valley of Sutton. Of the synclinal forms resulting from these anticlinal axes, the first, or northwestern one, ranges from Farnham through Lauzon ; the second from St. Armand to Shipton, (comprehending also the subsidiary double synclinal of Sutton Mountain) and continues from Shipton to St. Mary's, while the third ranges from the Owl's Head Mountain through Vaudreuil-Beauce."
- Anticlinale.**
- Synclinal forms.**
- Continuation of N. W. anticlinal axis.** In prosecuting the examination of the structure farther down the valley of the St. Lawrence, the axis of the northwestern anticlinal, which, as stated above, reaches the mouth of the Boyer River, is found to gain Margaret Island, about fourteen miles down the St. Lawrence, and Crane Island two and a half miles farther in the same direction. What may be its position still farther down the river remains to be ascertained, as the few islands to the northeast, which may occur in its course, have not yet been examined.

POTSDAM GROUP.

- The rocks between these two anticlinals, in the country above the Chaudière, belong wholly to the Quebec group ; but early in the progress of the investigation below this stream it became evident that another series, differing in character from those farther west, comes to the surface in part of this district. These rocks have heretofore been classed with those of the Quebec group, but they appear to underlie them unconformably, and being in some places marked by fossils which Mr. Billings considers to be of Potsdam age, they are now placed in the upper part of the Potsdam group. Described in descending order, and in general terms, these rocks are as follows :

Quartz rock.

1. Light drab quartz rock, weathering white, with a very vitreous looking surface, sometimes becoming a gray quartzose sandstone ; both holding disseminated flakes of black and greenish shale and occasional pebbles

Fl.

Fl.

of gray limestone. The mass is divided into beds varying from six inches to twenty feet, at the junctions of which there is often a layer of from a quarter of an inch to an inch which is calcareous and weathers to a grayish brown. At the base there is a thickness varying from a few feet up to seventy or eighty feet of conglomerate holding limestone pebbles, mingled with a few of white quartz, in a calcareo-arenaceous matrix; in some places the whole is interstratified with beds of black shale, generally slightly arenaceous, the shale increasing in abundance toward the base..... 600

2. Gray sandstones weathering to a drab, interstratified with black and gray argillo-arenaceous shales; some of the beds are from five to six feet thick, interstratified with calcareo-arenaceous bands of from one to six inches thick, as well as lenticular layers varying from one to three feet in the thickest part; these calcareous masses weather grayish-brown. The sandstones are often conglomerate in character, with pebbles up to half an inch in diameter consisting of white quartz, white feldspar, and gray limestone. In many places there appears at the base a conglomerate with limestone pebbles and boulders in a calcareo-arenaceous matrix; the thickness of it varies from ten to fifty feet, and the enclosed masses are generally one or two pounds in weight; some of them, however, would reach half a ton..... 700

3. Gray limestones and limestone conglomerates in beds from one to six inches thick. These beds are interstratified with black limestones and black shales, as well as with gray sandstones in beds from one to six inches thick. A *Salterella* was observed in the limestone. The conglomerates are often lenticular, the masses being from one to six inches thick and from one to ten feet long. Black nodules, some of them phosphatic, are common in the conglomerates. The thickness of these beds is about 100 feet, and they are underlaid by red, green, black and lead-gray shales, and hard arenaceo-calcareous argillites, interstratified with gray sandstones, varying in thickness from six inches to ten and even fifteen feet; some of the shales are interstratified with a few layers of gray arenaceous limestones from two to six feet in thickness, associated with the red shales. Lenticular masses of limestone conglomerate are occasionally enclosed in the gray limestones and red shales; black phosphatic nodules are disseminated in scattered patches, and a sponge of the genus *Archeocyathus* was met with in the shales..... 1000

The most westerly exposure of this series is brought into position by a undulation or probably a fault, which would meet the Boyer anticlin obliquely near the line dividing St. Anselme from St. Henri in the seignior of Lauzon; and as the rock is at a lower horizon than any on this part the Boyer axis, the disturbance bringing it to the surface is perhaps, rather than the Boyer, to be from this point considered the main continuation the anticlinal coming through Stanbridge. This most westerly exposure is about two miles west of the village of St. Gervais, in the fief La Martinière. The rock is a gray moderately coarse-grained hard sandstone; it is supposed to belong to the second of the divisions given (2), and what is seen of dips to the eastward. In Lévaudière, to the west of the village mentioned

an exposure of quartz rock presents itself, likewise dipping to the eastward; it would overlie the previous exposure, and is considered to be a part of the uppermost division (1). Strips of this rock occur on the road, and to the north and south sides of it, for two miles to the north-eastward, and one of the exposures, a mile from the village, and south of the road, is associated with a conglomerate about twenty feet thick, holding limestone pebbles in an arenaceous base. The breadth, comprehending all the exposures here, appears to be about a mile and a half.

Continuing northeastwardly, rocks of the division 1 are seen occasionally to within two miles of St. Raphael church, and again on Rivière du Sud at Le Sault, which is ten miles from St. Gervais. This last locality is in the seigniory of St. Vallier, and about a mile and a quarter north of St. Raphael church. The quartz rock of the division 1 is here interstratified with black shale, and the strata are much affected by overlap folds, leaning to the northwest, which are displayed on the river banks, the higher and lower dips of the opposite sides of the folds inclining to the south-eastward. Strips of the quartz rock continue to the village of St. Pierre, in the seigniory of Rivière du Sud, where a considerable exposure occurs. About a mile and a-half southwest from St. Thomas there is an exposure between the St. Pierre road and the Rivière du Sud, occupying a breadth of 200 paces, with a dip S. 81° E. $< 80^{\circ}$ – 90° ; and a mile south-east from the village there are others, which spread to a breadth altogether of two and a half miles. They are limited on the southeast side by the red sandstones and shales of the Sillery formation. This member of the Quebec group skirts the quartz rock all the way to within three miles of St. Gervais, a distance of twenty miles, while for the remaining six miles to La Martinière, they are bounded by the Lauzon formation. The Lauzon bounds them also on the northwest from La Martinière to within four miles of the position to which we have arrived, but for these four miles they appear on that side to be in contact with the Sillery; this general arrangement shewing the want of conformity between the higher and lower groups.

The quartz rock makes a much more conspicuous figure below St. Thomas than above, and forming bold ridges and hills, it often shews large areas of bare white rock. In this direction it passes through Lepinay, St. Joseph, Ste. Claire, Vincelot, the south part of l'Islet, and the north part of Lessard, as far as the Arago road. The sandstones of the succeeding division (2) emerge from beneath it on the northwest the whole way. The Arago road, running to the southeast, starts from the coast about a mile above the village of l'Islet. On this road these sandstones rise from beneath the Sillery formation, about three miles and a tenth from the coast, and occupy a breadth of two miles and seven tenths to the base of the quartz rock, the width of the latter being two miles. The Sillery

bounds this on the south-east side, all the way from Lepinay, with the exception of a patch of the Lauzon, which covers part of it, and narrows the band to less than half a mile on what is called the Cape road, running southeast from Cape St. Ignace.

Following up the quartz rock to the northeast, it is traceable through the remaining portions of l'Islet and Lessard, and through Port Joli and Fournier to the Elgin road, a distance of twelve miles, flanked on its south-eastern outcrop by the Sillery almost all the way. The sandstones (2) which rise from beneath it on the northwest, maintain at the summit the same course they exhibited above the Arago road for two miles below it, and then turning more northward for about two miles, widen out considerably. They are seen in several places between the Grand Trunk railway and the coast, as far as the Elgin road station, before reaching which they are spread out northward by undulations, and come upon the coast a short distance below the village of St. Jean. Some distance above St. Jean the coast appears to be occupied chiefly by Lauzon rocks, but just at the outer end of the wharf at l'Islet, there occurs an exposure of sandstone associated with limestone conglomerate, which may belong to this division (2), but whether connected with that below St. Jean by a continuous outcrop under the water it is difficult to say.

At and near St. Jean there emerges from beneath this division (2) on the coast, and runs through the village, a lower series of strata, the upper part of which consists of gray even bedded limestones, accompanied by conglomerates with limestone pebbles in a calcareo-arenaceous paste, both of them containing black phosphatic nodules, and both divided into beds of from an inch to a foot in thickness, and interstratified with black shales. These belong to the summit of the next and lowest division, and are succeeded, less than a mile above the village, by the following section in descending order, belonging to the same division (8):

Fl.		
Reddish even bedded limestones, interstratified with red shale, the red shale becoming more abundant in the lower twenty feet.	30	Division 8.
Reddish even bedded limestones, in layers of from one to eight inches thick, with lenticular patches of conglomerate holding calcareous pebbles in a calcareo-arenaceous paste, the patches being from half an inch to six inches thick, and eight feet long.....	35	
Gray compact slightly calcareous argillite.....	4	
Red shale.....	5	
Red and lead-gray shale.....	20	
Lead-gray soft shale.....	24	
		118
To this, about 320 paces up the coast, succeeds the following section, which is supposed to be an immediate continuation of the last.		
Gray sandstone.....	45	
Lead-gray shales and gray sandstones.....	60	

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	Fl.
dark shales, interstratified with gray hard calcareous	
beds of from one to two inches thick.....	15
dark shale.....	8
with gray compact layers of calcareous argillite, less	
than in the upper and lower ten feet.....	39 167
	<hr/> 285

On the coast road over the sandstones (2), the limestones and shales soon again appear, and are traceable to the coast end of the Elgin road. This road runs into the interior southeastward across the syncline, on it, after passing over some red and green shales, the dark limestone and sandstones of 3 plunge beneath the sandstones over the margin of the river. Several minor undulations here affect the sandstones (2) are seen crossing the road about a mile beyond the railway station. The quartz rock (1) is seen on the east side of the road, but through the influence of undulations it is not nearer than a mile from the depot. About three quarters of a mile northeast of the road, the base of the sandstones and quartz rock are seen within 300 yards of one another, with a dip of 1°. This would give to the sandstones a thickness of about 100 feet. On the Elgin road the quartz rock occupies a breadth of a mile in a general synclinal form, with many minor undulations, the trough extends to the southwest, with several tooth-like ridges for about a couple of miles. Farther southeast on the road are seen for three and a half miles are gray sandstones (2); a quartz bluff occurs on the southwest, forming the extremity of the anticline. The outcrop of the quartz rock presents itself, turning to the east on the axis. The flanks of the ridge run southwestward on one side and east on the other. The area occupied by the quartz rock as it proceeds to the southwest, and ultimately, by the aid of the syncline, attains a breadth of three miles, forming a high rugged country.

In the distribution of the quartz rock and the sandstones, as has been described, it will be evident that we have here the same synclinal form in the quartz rock, which extends all the way to the neighborhood of St. Gervais, a distance of about fifty miles, and comes to the northwest of it, on the Elgin road, stand in an anticline between this synclinal and another in the quartz rock on the coast. In the run of the more southern synclinal there is a continuation of quartz rock to the northeast, if we except a small irregular patch, less than a quarter of a mile long and a hundred yards wide, which crosses the Elgin road at the sixth mile-post from the front

of Ashford and Fournier, and sinks beneath the Sillery immediately beyond, seemingly in the strike of the quartz rock farther to the southwest. This may possibly have some outcrop connection with the main area of the rock, but there is not at present any means of proving it; and we shall therefore now proceed to describe the farther distribution of the Potsdam series, as connected with the northwestern synclinal.

From the Elgin road the sandstones which bound the quartz rock of this synclinal on the southeast side, run across various seigniories and townships to the Lac de l'Est road, and into Woodbridge, a distance of about twenty-five miles, maintaining a pretty regular course, limited all the way by the Sillery formation, but gradually narrowing from six to a little more than two miles. On the coast the shales of the lowest division (8) are well exposed from the Elgin road to the neighborhood of St. Roch, and on the beach immediately above St. Roch the even bedded limestones of 3 have afforded one or two specimens of a fossil, decided by Mr. Billings to be a *Salterella*, about the size of *S. Macullochi* from the Lower Quartz rock of Scotland. Inland from this these limestones appear to alternate with the sandstones either by interstratified beds of passage or by undulations, possibly by both, as far as the railroad, and a little south of it. The rocks of the division 3 are again seen at the mouth of Rivière Ouelle, where there are gray calcareous sandstones interstratified with a few layers of gray arenaceous limestone from two to six inches thick, associated with occasional red shales. Enclosed in the grey limestones and red shales, there are short lenticular layers of limestone conglomerate, with the calcareous pebbles of which are mingled rounded nodules, some of which are chiefly phosphate of lime; and it was among such nodules as these that occurred the phosphatic cylinder, mentioned in the Geology of Canada, p. 259, and there compared with *Serpulites*. In one of the pebbles of the conglomerate was obtained a fossil form, which Mr. Billings considers to be a sponge of the genus *Archeocyathus*. Rocks of the same character occur in good exposures on the coast from Point Iroquois to Pointe aux Orignaux; thence to St. Denis, and northward at Cape Diable. Rounding Kamouraska Bay they are concealed, but reappear two and a-half miles above Kamouraska church, and form a ridge from a quarter to half a mile wide, as far as the church; but gradually narrowing they disappear under the water over a mile beyond it. Half a mile east of the church the following ascending section occurs:

	<i>Ft. In.</i>	
Gray limestone conglomerate.....	5 0	Section near Kamouraska.
Red shale.....	2 0	
Gray limestone conglomerate, with black nodules in scattered patches....	0 9	
Gray shale with interstratified beds of compact gray limestone of from one to two inches thick.....	3 0	
Red shale.....	1 6	

	<i>Ft.</i>	<i>In.</i>
Pinkish compact limestone with enclosed lumps of red shale.....	1	6
Gray limestone conglomerate.....	1	0
Red shale.....	4	0
Red shale with thin layers of compact gray limestone.....	0	9
Red shale with short lenticular layers of gray limestone conglomerate.....	5	0
Green shale with beds of gray limestone of from two to six inches thick....	30	0
Red shale with layers of grey hard calcareo-argillaceous sandstone.....	4	0
	58	6

Crow Island.

The rocks on Crow Island, which lies out in the St. Lawrence a little over a mile, are greenish-gray red and black shales, the latter interstratified with a few bands of gray limestone, holding rounded black nodules, which appear generally to accompany them. Burnt Island, which lies further out and lower down the river, was not examined, but Grand Island, which is still farther down, appears to be formed of the same measures. The following section, which is in ascending order on the northeast end of the island, apparently crowns an anticlinal axis :

	<i>Ft.</i>	<i>In.</i>
Section, Grand Island. Lead-gray shales, interstratified with some black shales.....	18	0
Gray compact quartzite.....	1	3
Lead-gray shale, with yellow weathering calcareous nodules of a sub-cylindrical shape and from one to two inches long.....	10	0
Gray compact limestone.....	0	6
Lead-gray shale, interstratified with layers of black shale.....	25	0
Lead-gray shale, with yellow weathering calcareous sub-cylindrical nodules.	12	0
Lead-gray shale with thin black layers.....	5	0
Gray brown-weathering dolomite.....	0	4
Lead-gray shales with black shale layers.....	50	0
	122	1

All the strata seen on the island resemble those of this section, and the rocks on this and Crow Island shew a well marked cleavage, the underlie of which is S. 44° E. < 65°. On an island, apparently in the strike of Crow Island, there is a band of light gray pure limestone from ten to twenty feet wide, associated with lead-gray shales resembling those of the section.

On the coast these shales and limestones (3) are not seen from the spot mentioned near Kamouraska to a position some five or six miles below the village of St. André. Here they run along the margin of the river in a narrow strip to a point nearly two miles below the Temiscouata Portage road in the seigniory of Rivière du Loup, and they appear to be overlaid to the southeast by the Lévis formation, shewing some of its graptolites, and by the Lauzon beyond.

Temiscouata Portage road.

The limestones and shales of 3 again appear at the point outside of the mouth of River du Loup, and they are seen on that on which the village

ated, from which they extend about two miles beyond. Cacouna.
 appear to be covered by the gray sandstones (2) and the
 but they appear on the coast opposite Trois Pistoles, just Trois Pistoles.

gray sandstones (2) northeastward from the Elgin road
 in all cases true to their position between the limestones
 and the quartz rock (1), as far as Trois Pistoles and
 quartz rock below the same road, spreads out greatly
 a little before reaching the line between the seigniory of
 Mais and Ste. Anne. Just west of that line, however, the St. Roch and
Ste. Anne.
 covers it up, except where two elevated domes of no great
 of two small anticlinal folds, protrude through the newer
 stern edge of the quartz rock, farther north, through the
 ar undulations, shews nine long projecting synclinal points
 e coast some distance above Ste. Anne village.

of the effect of these numerous subordinate undulations Subordinate
undulations.
 synclinal in the quartz rock, which has its axis two or
 zes to the southeast of the Ste. Anne college, and is trace-
 course of S. 60° W. to near the coast, five miles distant.
 ist two miles of this distance the breadth of the synclinal
 is not exceed 250 paces. These undulations produce many
 hills, rising on the anticlinal crests to heights of from 200 to
 e plain. From the point of the long synclinal form which
 tioned to a position about two miles below St. André no less
 aty projections of a similar character, though less in length,
 l run of the quartz rock, giving it on the map the figure
 hile between these synclinals the quartz-shielded anticlinals
 is like islands from the clay-covered plain, giving to the
 t not seen anywhere else. In the neighborhood of Ste. Ste. Anne
 f these mound shaped masses. One is on the north side
 and a-half miles above the Ste. Anne station. Another is
 de of the road, two miles along the road, and seven-eighths
 utheast of it. This one rises to a height of 504 feet above
 17 feet above its base. A third rises with a height of 250
 to the west of the village, giving to this, with its college
 a very cozy and sheltered aspect.
 section was obtained at the last named hill, and may be con-
 correct representation, in ascending order, of the great
 e rock (1), wherever it was seen :

conglomerate holding pebbles of quartz and limestone,
 he latter being by far the more numerous, and varying in size
 eighth of an inch to one and two feet in diameter. The

Pl. n.

		<i>Ft. In.</i>
Section of quartz rock, Ste. Anne.	pebbles are imbedded in a very arenaceous limestone ; on account of the <i>débris</i> and bushes at the base of the hill the thickness is somewhat uncertain.....	80 0
	White quartz rock in one bed, with brown-weathering calcareous masses of irregular shapes and not sharply defined.....	6 0
	White quartz rock in one bed, with calcareous masses of the same character as before, some of them three and four feet in diameter.....	11 6
	White quartz rock as before, in one bed.....	4 0
	White quartz rock of the same character, too much broken to determine the thickness of each bed.....	130 0
	White quartz rock of the same character, in seven beds of from three to eight feet thick.....	50 2
	White quartz rock, approaching in character a quartzose sandstone, in several beds.....	24 0
	White quartz rock in eight beds, varying in thickness from three and a-half to thirteen feet.....	66 0
	Measures concealed.....	12 0
	White quartz rock, with thin lenticular patches of a calcareous character conformable with the bedding, occurring at intervals of from two to six feet, the whole forming one bed.....	21 6
	White quartz rock, in two beds of three and five feet respectively.....	8 0
	Brown calcareous sandstone in two beds.....	11 6
	White quartz rock, without calcareous matter, in several beds.....	55 0
	Gray quartzose sandstone, in one bed.....	10 6
	Measures concealed, supposed to be black shale.....	13 0
	Gray sandstones, partly concealed.....	14 0
	Gray thin bedded sandstone.....	7 0
	Black shale dipping N. 10° W. < 63°.....	4 6
	Measures concealed, probably black shale.....	21 0
	Black shale with interstratified gray hard arenaceous beds from one to two feet thick.....	31 0
	Measures concealed, but supposed to be black shale and interstratified sandstone.....	15 0
		<hr/> 595 8

High falls.
River du Loup.

Green Island
River.

The northern edge of the quartz rock (1) leaves the coast at St. Anne, and the strata are exposed, as has already been indicated, in a number of ridges, many of them remarkably bold, through St. Denis and Kamouraska, regaining the margin of the river about two miles below Kamouraska church. In consequence of the undulations the quartz rock is seen alternately with the sandstones (2) nearly all the way. They continue thence to Ste. Anne, and about three miles below the church of that village appear to sink under the Lévis and Lauzon formations. The quartz rock is again seen in a narrow strip which crosses the River du Loup below the High falls, while the sandstones associated with black shales (2) come from beneath the quartz rock lower down the river, and are exposed to its mouth. Below River du Loup the sandstones are exposed almost continuously to the mouth of the Green Island River, and extend along the coast still fur-

ther to the mouth of the Trois Pistoles, the Potsdam rock being limited all the way on the southeast by the Lauzon formation.

On the south-east side of the more northern synclinal we have already followed the sandstones (2) to Woodbridge. Here trending more northward they turn round the end of a synclinal promontory of quartz rock, and then striking again north-eastward they cross Woodbridge, Granville, the adjoining parts of l'Islet du Portage and Bungay, and reach the Pohene gamook road, where they are upwards of a mile wide, and to which they are bounded on the south-east side by the Sillery. On the north-west they are limited across Woodbridge by the Lauzon formation, which, more to the westward, lies in a broad belt between the opposite out-crops of the general quartz rock synclinal; but across Granville and l'Islet du Portage they are limited by a somewhat narrow strip of quartz rock, which there emerges from beneath the Lauzon, but sinks beneath it again in Rivière du Loup, upwards of a couple of miles from the south-west line of that seigniory.

The quartz rock again emerges from beneath the Lauzon a little farther on in Rivière du Loup, and, accompanied by the sandstones (2) on the south-east, runs across the remainder of Rivière du Loup and the Temiscouata road, where the line between these divisions (1 and 2) strikes near the six mile post. Farther on, these divisions cross the north part of Whitworth, the west corner of Viger, and disappear north of Fraser's mill on the Green Island River, near the line between the last township mentioned, and the seigniory of Cacouna. They here sink beneath the Lauzon formation, which bounds the Potsdam rocks on both sides, from the middle of Rivière du Loup, and thus covered up they probably form the extremity of a trough.

On the north-east side of the Green Island River, in the seigniory of Isle Verte, about two miles from the south-west boundary, and eight-tenths of a mile from the coast, the quartz rock (1) again occurs, followed on the south-east by the gray sandstones (2) which as already stated, appear also on the coast in this neighborhood, thus giving to the quartz rock synclinal form, and in this arrangement it is pretty generally seen extending to Trois Pistoles River. This is as far as the examination reaches on the coast, with the exception of work extending about fifteen miles to the north-east, to connect the details of which, would require farther investigation.

In addition to the *Salterella* met with in the even bedded limestone (3) near St. Roch, the following fossils were obtained from the limestone pebbles of the conglomerates interstratified with the quartz rock (1) and those of the sandstones (2), in procuring which I was much assisted by Mr. T. C. Weston, whose painstaking perseverance and success as

GEOLOGICAL SURVEY OF CANADA.

own to you. One of the localities which proved fruitful at a mile north of the St. Denis station of the Grand Conglomerates at the base of the quartz rock at *alterella rugosa*, and undetermined species of *Theca* undetermined species of *Crania* and *Metoptoma*, an *Olenellus Thompsoni*, *Conocephalites Thompsoni* and of trilobites. From limestone pebbles of the conglomerate with the sandstones (2), at this place, in addition to *Yathus* was obtained, with new species of *Discina* and *Desquamata*, as well as new species of *Bathyrurus*, *Thompsoni*. A third and last locality is Bic Harbor; the pebbles of which the fossils were here obtained are the same horizon as the previous one. The fossils are *Discina*, *Kutorga cingulata*, new species of *Discina* and *rugosa*, *Olenellus Thompsoni*, a new species of *Bathyrurus*, *Conocephalites Adamsoni* and several other of undetermined genera. The whole of the fossils were determined by Mr. Billings.

QUEBEC GROUP.

It is to be said of the divisions of the Potsdam group; localities in which they were observed will be more fully treated with the description to be given of the distribution of the Quebec group, many allusions to which have been made in what has been written above. The fact that the rocks of the Quebec group have been so often described that it is not considered necessary to repeat on every occasion, and the only allusion I shall here make to the fact that in proceeding north-eastward from the gneissian deposits of the Lauzon division gradually the igneous rocks die out, and the metalliferous ores which rendered them so valuable disappear with them, leaving a barren prolongation of the gillaceous part to represent the formation. In this series the gneissian deposits are continued farther on the south-east, and while the general strike of the series is north-west, the line limiting the magnesian and metalliferous series is nearly east, at length becoming covered by the unconformable Silurian series, which bounds the whole group on the east.

Mr. Billings stated that the Bayer anticlinal axis reaches Mar-

garet and Crane Islands, the former about fourteen miles down the St. Lawrence. On Margaret Island, the probable base of the Lauzon formation presents a series of glauconite shales, similar to those of the Island of Orleans, from beneath which shales of the Lévis emerge, characterised by the frequent occurrence of graptolites, most of which are obscure, but among them there were procured one or two specimens of *Phyllograptus angustifolius*. These formations were again underlaid by unconformable black shales interstratified with bands of hard compact calcareo-arenaceous argillites, similar to those already described in division 4 of the Potsdam series.

Glauconite
shales.

Graptolites.

On Crane Island, the Lévis shales with graptolites are seen on the south-east side, but the main body of the island consists of the red and green shales belonging to the Lauzon. On the west end of the island a band of sandstone occurs, running north-westward, transverse to the general strike of the Quebec group measures, and probably belongs to the unconformable Potsdam beneath.

Crane Island.

Grosse Isle, lying to the north-west side of the Bayer and Margaret anticlinal axis, is composed of red and green shales, alternating with green glauconite shales inclosing irregular masses of gray limestone, belonging, as before, to the Lauzon formation; but on the north-east end of the island there is a band of conglomerate of twenty feet thick, which, from the preponderance of calcareous matter, would altogether make a tolerably pure limestone. The pebbles are small and consist of a compact gray limestone mixed with many small black nodules, some of them probably phosphatic. The matrix is a gray, yellow-weathering, slightly arenaceous limestone. In the absence of fossils it is difficult to decide whether the mass belongs to the Lauzon or to one of the divisions of the Potsdam series. Its relation to the shales is not always the same over the quarter of a mile in which it is exposed, so that it may belong to the inferior group.

Grosse Isle.

Limestone.

On the southeast side of the Bayer anticlinal and of the Lévis beds, which it brings to the surface on the Bayer River, the Lauzon presents itself, occupying the coast from St. Vallier village to Berthier and a mile below. From this it runs in a narrow strip to the south-west between the Lévis and the Sillery formations to La Martinière, where it rounds the end of the Sillery, turning under a synclinal axis, and running towards St. Thomas, occupies a place between the Sillery and the Potsdam rocks, as has previously been described.

Berthier.

The synclinal belt of Sillery, whose relation to the Potsdam rocks has been already given, runs north-eastward to the vicinity of the line between the seigniories of l'Islet and Port Joli. The rock then folds over an anticlinal axis at the St. Ignace station of the Grand Trunk railway; from this, minor undulations carry it northward to the village of St. Ignace,

Sillery synclinal.

and it occupies the coast from this to within a mile of Berthier. The Lauzon comes from beneath it at the St. Ignace station, and this formation occupies the coast down to the position in which it has already been indicated near St. Jean.

Sillery forma-
tion.

St. Pacôme.

Ste. Anne.

Of the Sillery formation nothing more is seen on the coast until reaching the neighbourhood of Cacouna, between which and the mouth of Green Island River it occupies the coast for about eight miles, with a probable breadth of about a mile and a half; but the Lauzon, as has already been indicated, lies in a synclinal belt on the north-western trough of quartz rock, stretching sixty miles down the valley of the St. Lawrence. The south-western end of this belt occurs near the line between the seigniories of St. Roch des Aulnais and Ste. Anne, and the rocks of the formation cross Ste. Anne with a very variable breadth, overlapping the Potsdam to a greater or less extent in different places. Near the River Ouelle station, at St. Pacôme, they almost entirely cover up the quartz rock on its north-west out-crop, while they lie in patches in their run from this towards Ste. Anne. One of these patches underlies that village, where the strata, consisting of red and green shale, with a few beds of gray limestone, are seen around the church. North-eastward of the River Ouelle they are seen across St. Denis and Kamouraska seigniories. About three miles and three quarters eastward from the St. Pascal station, in the latter seignior, in a brook close to the railway, a few obscure graptolites were met with in black shale, with red and green shale on the north-west, and gray sandstone on the south-east.

St. Alexandre

Crossing Granville, exposures of the Sillery formation occur about a mile south-east from the station of St. Hélène, on the line between Granville and Islet du Portage. They here form the south-western extremity of a trough, the north-west line of which crosses the railroad about two miles below the St. Alexandre station, where the trough has a breadth of about two miles. The Sillery trough terminates in this direction about a mile south-east of the present end of the Grand Trunk railway, at the River du Loup station. A pretty broad band of the Lauzon formation limits the trough on each side, the relations of which to the Potsdam rocks beyond have already been described.

Lauzon and
Lévis.

Fossils.

On the north-west side the base of the Lauzon runs somewhat close to the coast, and three miles south-west from the Portage church the black shales of the Lévis appear, cropping out from beneath, and shewing, by the effect of undulations, for a breadth of nearly two miles. South-east from the church, near the top of an escarpment that runs along the coast, in beds supposed to be somewhat higher than the Lévis, columns of crinoids were observed, as well as a small *Discina*, and fragments of an *Orthis* or *Rhynchonella*, but too obscure to be specifically determined. This escarpment of Lauzon, with probably a little of the Lévis at its base,

in its prolongation to the north-east forms the precipice of the High Falls of the River du Loup, and overlies the quartz rock of the Potsdam below. The distribution of the Lauzon farther on has already been given in describing that of the Potsdam rocks, and need not be here repeated. In Villeray, on a small brook falling into the Green Island River on the left bank, black shales, holding disseminated nodules of iron pyrites, and probably belonging to the Lévis formation, protrude through the Lauzon on the axis of an anticlinal.

There is a great sameness in the lithological characters of the Lauzon throughout the region examined. It consists in general of green and red shales, with bands of gray quartzose sandstone becoming white by exposure to the weather. These arenaceous bands seldom exceed twenty or thirty feet in thickness. In some places the green shales become very arenaceous, and they are occasionally characterised by bilobated fucoids, resembling those occurring in the sandstones of the Chazy formation on the Grenville canal and at other places in the valley of the Ottawa River.

Characters of
the Lauzon.

Throughout the whole distribution of the Lauzon thus far described thin bands of gray arenaceous limestone are frequently interstratified with the red and green shales. There are beds of this character, more conspicuous than usual, where the fossils mentioned were found near the Portage church, and a section met with about half-way between the Portage road and the village of River du Loup, three hundred paces north-west from the second range road of the seigniory, where the strata dip S. 70° E. $< 75^{\circ}$ — 87° , may be given as an example of their greatest development. Here fifteen feet of gray, tolerably pure limestone, with obscure bivalve shells, one of them an *Orthis* or *Rhynchonella*, are surmounted by twenty-four feet of gray, yellow-weathering, and probably magnesian limestone, with large and small spots that remain gray, giving a mottled aspect to the whole.

Fossils.

On both sides of the River du Loup, near the railway station, there are met with some moderately pure limestones, passing occasionally into limestone conglomerates. In the locality on the left side, the same obscure *Orthis* or *Rhynchonella* as before was met with. Along the road between the second and third ranges, a little north-east of the line between the seigniories of Rivière du Loup and Cacouna, there is a set of limestone conglomerates, interstratified with gray calcareous argillites and red and green shales, underlaid by a band of white quartzose sandstone of undetermined thickness. In the matrix of the conglomerate, which is a limestone differing very little in aspect from that of the pebbles, a coral was obtained, which Mr. Billings considers identical with *Stenopora fibrosa*, and an unnamed *Orthis*, the same as a species that occurs in the Lévis formation. The calcareous argillites yielded an *Ophileta*, and portions of a *Lingula*, with fragments of graptolites and trilobites. On one of the slabs along with these fossils a few specks of green carbonate of copper were observed.

Second main anticlinal.

The general course of the second main anticlinal from St. Mary's to the Temiscouata Portage road has been already indicated, and it now remains to describe the distribution of the Quebec group in the synclinals on each side of it, between the Potsdam series on the one hand and the Upper Silurian on the other.

N. W. synclinal.

In the north-western of these synclinals the Sillery, which is the highest rock, commences in a point in Ste. Marguerite, about a mile south-west from Ste. Marguerite church. From this the formation widens out rapidly to the north-east in Joliette, and in crossing the Etchemin River its breadth is two miles and eight-tenths, its northern limit being a little below Ste. Claire. On the line between Joliette and Buckland it is somewhat wider, its northern limit being on the fifth and its southern on the sixteenth lot, both of the first range of the township. On the St. Gervais road, in Livaudière, its width is nearly four miles, its north-west edge being about a mile north-west of St. Lazare, and its south-east on the fifteenth lot of the third range of Buckland. From this the northern base gains rapidly to the north, and when it comes upon the quartz rock of the Potsdam series, about three miles north-east of St. Gervais, its breadth to the eighth range of the Augmentation of St. Michel is ten miles.

Lauzon.

The Lauzon, coming from beneath the Sillery at the junction of the latter with the Potsdam rock, skirts this rock, as has heretofore been stated, to its termination in La Martinière, occupying a synclinal form, which extends to a point some miles beyond the Etchemin, and lies between the undulation or fault bringing up the Potsdam, and a minor anticlinal, which carries the black shales and limestones of the Lévis formation from St. Anselme on the Etchemin to the St. Gervais road, nearly a mile south-east from the village of that name. On the south-east side of this minor anticlinal the Lauzon has a direct breadth of four miles on the Etchemin, to the vicinity of Ste. Claire, and fills up the space between the river and the Sillery. Without reference to its figure in the north part of Joliette farther south-west, between the Etchemin and the Chaudière, it crosses the former stream, and follows the undulating run of the Sillery to the termination of this beyond Ste. Marguerite. It thence attains the Chaudière, on which it has a direct breadth of about three miles, in the form of a synclinal, its northern base being about a half a mile below, and its southern two and a-half miles above the village of St. Mary, the Lévis formation emerging on both sides beyond it. Between the Lévis and Sillery, on the south-eastern side of the latter, it becomes reduced by undulations to a very narrow band, between Ste. Marguerite and the Etchemin, where it measures from half to a quarter of a mile; but it widens again in Buckland, which it enters with a breadth of two and a-half miles, extending from the sixteenth to the twenty-fifth lots of the first range. In this distribution of the Lauzon

the magnesian band, which masks its base to the south-west, was represented by concretionary rocks, holding ovoid concentric shapes, in which serpentine often formed a constituent mineral. Through the influence of numerous undulations affecting the strata, these rocks sometimes occurred in unexpected places, and frequently occupied considerable areas, but they were always separated from the upper magnesian band, which marks the base of the Sillery, by some amount of argillaceous deposits.

Lower magnesian band.

On the Chaudière, the Lévis connected with the second main anticlinal, has a breadth of about nine miles between the Lauzon of the northern synclinal and that of the southern, which it meets about a quarter of a mile above St. Joseph church. From the Chaudière the Lévis runs north-eastward across the seigniories of St. Mary and St. Joseph to Joliette and Frampton, its north-western boundary running across the chief part of the former, a mile or two within its boundary, but reaching the line between the two in the tenth range of the township, and entering Buckland on the twenty-fifth lot. The southern boundary, passing into Frampton on the third lot of the first range, through the influence of undulations, soon gains the twentieth lot, reducing the breadth to seven miles. Farther to the north-east, this boundary leaves Frampton on the twenty-fourth lot of the eleventh range, crossing the Etchemin on the same lot. The formation occupies ten and a-half miles on the river, but its direct breadth here, across the measures, is a mile less.

Lévis on second anticlinal.

The Lauzon in this synclinal is about a mile wide on the Chaudière, and enters Frampton and Cranbourne with the same breadth, the north-west boundary being on the twenty-sixth lot of the first range of the former township, and the south-eastern about the middle of the first range of the latter. Proceeding north-eastward the band soon widens out to two and a-half miles, but contracts again to somewhat less than a mile before reaching the Etchemin River, its southern boundary being there between the twenty-sixth and twenty-seventh lots of Frampton.

The Sillery formation, including certain concretionary rocks, serpentines, and other magnesian deposits at its base, which however belong strictly to the summit of the Lauzon, but for convenience are joined with the Sillery (see Report 1866, p. 5), has a breadth of four miles on the Chaudière; the south-eastern limit, where they sink below the Upper Silurian, being three-quarters of a mile above the line between the seigniories of St. Joseph and Vaudreuil-Beauce. These concretionary rocks and serpentines are traceable to Cranbourne, and they are again seen on the twenty-seventh lot of the third and fourth ranges of Frampton. They also form several hills on the right side of the Etchemin, above a great bend in the river, running parallel with it to the north-east line of Cranbourne and some distance into Standon; from this they cross to the left side of the

Sillery.

Upper magnesian band.

river in Ware, where Mr. McOuat observed considerable exposures of them on the first, second and third lots in the sixth and seventh ranges, and on lot A in the eighth range of that township. Half a mile south-east from the third lot the black shales of the Upper Silurian series were observed.*

The region of country to the north-east, still to be described, is every where wooded, and the few roads which traverse it, though they cross the measures to the south-east, very nearly at right angles to the strike, are at considerable intervals from one another. In going over them the limits of the formations are observable in many places; but it will be easy to understand that of the numerous undulations which may, and probably do occur, a great many must escape detection, though some may be conjectured; and it is, therefore, only a mere general outline that can be given in the geographical distribution of the formations.

Road S. E. from
St. Raphael.

The first of these roads, which is about eight miles to the north-east of St. Gervais, starts from St. Raphael, and in following it from this point, passing over the quartz rock of the Potsdam, the red and green sandstones and shales of the Sillery are almost immediately seen, beginning about a quarter of a mile from St. Raphael church. They are pretty well exposed up the River du Sud, and through Armagh, the road gradually, by various oblique offsets, gaining a more north-easterly position than at St. Raphael; and the last exposures of the Sillery trough occur on the eighth lot of the west range of the River du Pin settlement in Armagh, which would give to the trough a direct south-easterly breadth of a little over twelve miles, with a distance of fourteen miles from the St. Gervais road near St. Lazare. The Lauzon formation is supposed to occupy the next four miles of the road; the exposures, however, are not many, and those which occur consist of green shales, interstratified with black bands in some places. Beyond this a distance of a mile and a-half on the road is occupied by the black shales of the Lévis formation, and these are succeeded, on the south side of the anticlinal axis, by a repetition of the Lauzon, which extends to the line between the twenty-ninth and thirtieth lots of the north-east and south-west ranges of Roux. In a farther distance of a mile and a-half the red and green sandstones of the Sillery are pretty well exposed, beyond which, after an interval of concealment, the black shales of the Upper Silurian present themselves.

Road S. E. from
St. Thomas.

The next traverse that was made was on a road about fifteen miles north-east from the last, running nearly south-east from St. Thomas. On this road the Potsdam and Sillery are seen nearly in contact three and a-half miles from the village, as has already been stated. From this the Sillery

* These deposits, and their distribution in the neighbourhood of the Chaudière are described in the *Geology of Canada*, pp. 254 and 255.

occupies a direct breadth of about eight miles, its south-eastern limit occurring a little farther on than the thirty-first lot of ranges A and B of Ashburton. Beyond this the Lauzon extends to the line between the second and third ranges of Montminy, where it is seen on the fifteenth lot, giving to the formation a breadth of six miles. The Lauzon formation is succeeded by the black shales of the Lévis, which extend a little over seven miles to the Lauzon on the other side of the anticlinal axis, the base of the formation occurring a little beyond the line between the second and third ranges of Rolette, on the sixth lot. To the south-east and east of this the rocks are of a tolerably uniform character. They consist of green shales, with an interstratification of a small amount of red, over a breadth of a mile and a-half, and are supposed to represent the Lauzon formation. Half a mile beyond this the road turns nearly due east to the Province line. For the first two and a-half miles rocks of the concretionary character already mentioned as at the base of the Sillery are almost continuously exposed, and at the end of the next two miles considerable masses of serpentine occur, to the west of a tributary of the Black River, from the tenth to thirteenth lot of the sixth range of Talon. Nearly two miles to the east of the stream a few small exposures of lead-gray slates are seen, supposed to belong to the Upper Silurian series.

Serpentine.

Fifteen miles to the north-east of this Government road is the Cape St. Ignace road, which afforded the opportunity of the next traverse. It has been already stated that on this road a strip of Lauzon, a little over a quarter of a mile wide, occurs, resting on the Potsdam quartz rock, near the base of the overlying Sillery sandstones. This patch of Lauzon has but a short run to the south-west; but in the opposite direction it extends a mile and a-half, with the quartz rock around the end and on both sides of it, that on the south terminating in a point close to the south-west. Passing over this point of quartz rock, we meet the north-west base of the Sillery. As the road was not cut through to the south-west base of the Sillery trough it was not considered expedient to continue this traverse on it. The north-west base of the formation was therefore examined to the Arago road, which afforded the next traverse, about four miles to the north-east. This base of the Sillery crosses the road about a quarter of a mile south-east from St. Cyrille, beyond which the formation rises into considerable hills, and is well exposed for six miles on the road to its southern limit. No exposures of the Lauzon, however, were met with on the road to the south-eastward, for a distance of three miles farther, beyond which the road had not been opened.

Cape St. Ignace road.

Arago road.

On the Elgin road nearly twenty-five miles farther to the north-east, the Sillery rocks have a breadth of about five and a-half miles, their north-western limit occurring, as has already been stated, at the sixth mile-post

Elgin road.

from the front of Fournier and Ashford, and their south-eastern at the line between Fournier and Garneau. Few exposures, however, belonging to the formation, were seen on the road, but its presence beneath was inferred from the character of the country, and the occurrence of large loose angular blocks of red and green sandstone which, at intervals, almost paved considerable areas, quite unfitting them for agriculture. The breadth assigned to the Lauzon on this road is about four miles, extending to the Taché road between the fifth and sixth ranges of Garneau. But few exposures, however, of the formation were met with. These consisted of occasional gray sandstones, and one of red and green shale seen on a branch of the River Ouelle, about a mile and a-half from the northern limit. The surface, however, presented the usually rolling character which belongs to the country underlain by the formation, and appeared generally fit for settlement, while a short distance beyond the limit given to the formation, the black shales and quartzites of the Lévis became exposed. These are seen on the road, at intervals, for a distance of three miles and three-tenths from the Taché road, which may be considered the breadth of the formation here. Immediately beyond the boundary of the Lévis rocks, there occurs, on the north-east side of the Elgin road, an exposure, which although only two paces wide, was sufficient to show the existence here of concretionary rocks similar to those several times already referred to; but these must here belong to the base of the Lauzon instead of its summit. After an interval of concealment of somewhat over a mile, black clay slates and grayish-green sandstones prevail on the road, as far as the Province line. These are considered to be of Upper Silurian age, and consequently cover up a part of the Lauzon, and the whole of the Sillery, on the south-east side of the second anticlinal axis.

Concretionary
rocks.

There is an intervening space of twenty miles between the Elgin road and the Lac de l'Est road. It has already been stated that on this road the Sillery comes upon the Potsdam rocks eleven miles from the coast. The breadth of the formation is here eight miles, the south-eastern edge being close upon the line between the thirty-eighth and thirty-ninth lots of the ranges A and B of Painchaud. Beyond this the Lauzon occupies a breadth of two miles; and farther on, the rocks, although not well seen, they are supposed to be Upper Silurian.

Lac de l'Est
road.

On a short excursion from St. Pascal, nearly six miles more to the north-eastward than the last road, the Sillery is seen on the south-east side of the River du Loup, from the above village. It is succeeded in less than a couple of miles by red and green shales, with some gray limestones, resembling those at River du Loup supposed to belong to the Lauzon formation. What breadth this band of Lauzon may have before again meeting the Sillery farther on, I am not able to say. It is probable, how-

St. Pascal.

t wide, for it does not appear on the Lake Pohenegamook ^{L. Pohenegamook road,} miles to the north-eastward, on which the first Sillery Potsdam rocks is in the strike of the first Sillery on the St. Lawrence north-east of which the formation must close over Lauzon, as the red and green sandstones of the Sillery exposed on the Pohenegamook road, from their first the Potsdam rocks, a mile north-west of the line between Rivière du Loup and Parke, to the line between Parke and somewhat over eleven miles. Beyond this the Lauzon is of a mile and a-half, where it becomes clearly overlaid by Silurian rocks, which are seen forming rounded hills to and Pohenegamook Lake, as far as the Province line, and beyond. The first road on which these rocks have been examined is Temiscouata Portage. ^{Temiscouata road.} Here the Lauzon is seen just south of the St. Lawrence River, and has a breadth of three and a-half miles. The outcrop of the Sillery, near the thirteenth-mile post, which

The breadth of the Sillery, south-eastwardly, is a little which brings it nearly a mile south-east of the line between Rivière du Loup and Parke. It is then followed by the Lauzon, which continues beyond St. Honoré, its breadth on the road being over six miles more than five at right angles to the measures. The rocks are very much alike on both sides of the synclinal, consisting of red, green and black shales, interstratified with sandstones, while the intermediate Sillery consists of sandstones interstratified with red shales. The Lauzon is crossed by the Lévis formation, which extends to a valley at the thirty-fourth mile post, beyond which, on the east side, the Silurian appears.

ECONOMIC MINERALS.

examined the unexpected occurrence of a series of rocks ^{Economic minerals.} of the Quebec group rendered it necessary to devote a great amount of time than usual to the elucidation of the structure, and attention was paid, as occasion served, to the search for minerals. The gradual disappearance of the magnesian and siliceous rocks of the Lauzon formation, as we proceeded down the St. Lawrence, rendered our efforts unavailing. Of all the minerals which appear in so many places above the Chaudière the only one observed was confined to the few specks of green calcareous material already mentioned as occurring a little north of the line between the Rivière du Loup and Cacouna.

Gold.

Although there are indications of gold in the Quebec group in the Eastern Townships, the presence of the metal on the Chaudière, both in the alluvium and in quartz veins, appears to be more general in the country underlain by the Upper Silurian series. Its occurrence, as associated with this series on the Chaudière, and for some distance to the north-east, has been stated in various Reports since 1846; but as the structural examination usually stopped at the base of this series, a search for the economic minerals which may characterize the Upper Silurian still farther on must be deferred to a future time. Where these rocks occur around Lake Pohenegamook they appeared to me to afford the most favorable place for an investigation of them. They are here characterized by many lenticular veins of white quartz of from one to six inches in thickness, running with the stratification, and although no visible gold was observed in them, and several trials of the alluvium were not rewarded with success, it is quite possible that a more systematic search may shew the presence of the metal. The only substances of economic value I have, therefore, to report are bog iron ore, building stones and peat.

Bog iron ore.

Bog Iron Ore.—Several localities in the region examined have already been reported in St. Vallier, (see *Geology of Canada*, p. 684). To

Kamouraska.

these I have to add two in the seigniory of Kamouraska. One of them is on the north-east side of the road between the villages of Kamouraska and St. Pascal, and nearly a mile from the latter, where a small deposit occurs at the south-east foot of a conspicuous bluff of quartz rock. It extends north-eastward along the bluff for about a hundred paces, and is three or four paces wide, with a thickness of from two to four inches.

Manganese.

Another deposit occurs about three miles south-west from the last, on the north-west edge of a ridge of quartz rock. It is associated with wad or black oxyd of manganese, as well as with yellow ochre, and is seen on the road, and alongside of it, for 300 paces, with a breadth of thirty paces and a depth of from six to eight inches.

Building stones.**Quartz rock.**

Building Stones.—Throughout the district material for building purposes is abundant. The quartz rock of the Potsdam series is well adapted for such. It furnishes in many places near the railroad, all the way from St. Thomas to River du Loup, a fine white quartz or sandstone, which is often free from stains, and the section given at Ste. Anne, p. 128, shews that the deposit would yield blocks of any required size. It is a durable rock, which is not only capable of resisting the weather, but may be considered fire-proof.

Conglomerates.

The conglomerates associated with the quartz rock are likewise well suited for building. They also are widely distributed along the line of railway from St. Thomas to River du Loup, and thence along the coast to Bic, where no doubt they will attract the attention of railroad contractors.

REPORT OF MR. JAI

As examples of the use of the rock for the railway bridges across the Rivers from which the material of these bridges is obtained, about half a mile south-east from the

The Sillery sandstones likewise a purposes. These sandstones, however respect to the railroad as the rocks pr

Peat.—Peat bogs in the seigniorie
 Ouelle have already been described

In addition to those mentioned one of Loup, toward the south-west side, above the St. Lawrence, extending about three miles with a breadth of half a mile, and from which occurs in the seigniory of l'Islet du Fort the Ste. Helène station. It has a northward extension of two miles, with a breadth of a quarter of a mile. The first was eight and ten feet respectively.

south-east from St. Denis station. It
with an ascertained depth of eight feet
de l'Est road south-westerly, but how
not ascertained.

I have the honor

Sir,

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REPORT

OF

MR. HENRY G. VENNOR,

ADDRESSED TO

SIR WILLIAM E. LOGAN, F.R.S., F.G.S.,

DIRECTOR OF THE GEOLOGICAL SURVEY OF CANADA.

MONTREAL, May 1, 1869.

SIR,—Early in May of 1866 you were pleased to direct me to commence a series of explorations in the township of Madoc, in the North Riding of Hastings County, Ontario, and, starting from that township as a centre, to proceed to make a detailed examination of the rocks through Hastings and the adjoining counties, and to take particular note of all mineral deposits of economic value. The explorations then commenced were continued during the ensuing seasons of 1867-68, and I now beg to lay before you, in a somewhat condensed form, the substance of my Reports for those years accompanied by a colored geological map on the scale of four miles to an inch.

The country examined covers an area of about 194 square miles, being bounded on the north by the Peterson and Mississippi road lines and the Opeonga road; on the south by the Silurian limestones between the townships of Sheffield and Belmont; on the east by the Addington road running through Addington County; and on the west by the Burleigh road in Peterboro' County.

Region
examined.

The townships which have been the most explored, and of which I have prepared a geological map, are Madoc, Marmora, Elzevir, Lake, Tudor and Grimsthorpe, in Hastings County; Kaladar and parts of Anglesea, in Addington County; and Belmont and Methuen in Peterboro' County, to the rocks of some of which allusion has already been made in former Reports. Besides these surveys I also made a traverse as far north as the York Branch of the Madawaska River, on the Hastings road, between the

Geological
map.

townships of Faraday and Dungannon; on the east a survey, partly by chain and partly by pacing, of the Addington road, from the town line of Sheffield, as far north as the head of Mazinaw Lake, in the township of Abinger; and to the west a survey of the Burleigh road as far as the township of Cardiff. These last traverses were made in connection with my central work, with a view of determining, if possible, the extent of the dolomites, mica-slates, conglomerates and schistose limestones of this region, which, as you are aware, differ considerably in their lithological characters from the great mass of the Lower Laurentian rocks. Much information with regard to the geology of parts of the district is found in the Report of Mr. Murray for 1852-53, and in that of Mr. Macfarlane for 1866, and the results of these explorers have greatly aided me in my investigations.

Rocks of Hastings County.

Ascending section.

An ascending series of the rocks was prepared by me in 1866, and was published by you in the Quarterly Journal of the Geological Society of London, for 1867, and subsequently in the Canadian Naturalist; the object, at that time, being to shew the geological position of the remarkable fossil *Eozoon Canadense*, which had been found at the summit of the series in Tudor. This section, which is here repeated, was made from the results of my explorations in the townships of Elzevir, Madoc, Marmora, Belmont, Lake and Tudor, the average thickness of each mass having been deduced from numerous exposures in the different townships. For reasons which will be apparent in the course of the Report it is found desirable to divide the section into three parts, which will be represented by distinct colours in the accompanying map.

DIVISION A.

		<i>Feet.</i>
Lower division.	1. A great mass of highly crystalline syenitic rock generally deep red, but presenting varieties in texture and in color, without apparent stratification, so far as yet observed. Thickness not ascertained.	
	2. Reddish and flesh-coloured granitic gneiss, the thickness of which is unknown; estimated at not less than.....	2000
	3. Greyish and flesh-coloured gneiss, sometimes hornblendic, passing towards the summit into a dark mica-schist, and including portions of greenish-white diorite; mean of several pretty closely agreeing measurements	10400
	4. Crystalline limestone, sometimes magnesian, including lenticular patches of quartz, and broken and contorted layers of quartzo-feldspathic rock, rarely above a few inches in thickness. This limestone, which includes in Elzevir a one-foot bed of graphite, is sometimes very thin, but in other places attains a thickness of 750 feet; estimated as averaging.....	400

DIVISION B.*

Feet.

- | | |
|---|-------------------------|
| 1. Hornblendic and pyroxenic rocks, including several varieties of diorite and diabase, both massive and schistose, occasionally associated near the base, with dark micaceous schists, and also with chloritic and epidotic strata, including beds of magnetite; average thickness.... | Middle division
4200 |
|---|-------------------------|

DIVISION C.

- | | |
|---|------------------------|
| 1. Crystalline and somewhat granular magnesian limestone, occasionally interstratified with diorites, and near the base with silicious slates and small beds of impure steatite..... | Upper division.
330 |
| This limestone, which is often silicious and ferruginous, is metaliferous, holding disseminated copper pyrites, blende, mispickel, and iron pyrites, the latter also sometimes in beds of two or three feet. Gold occurs in the limestone at the village of Madoc, associated with an argentiferous grey copper ore, and also in irregular veins with bitter-spar, quartz, and a carbonaceous matter at the Richardson mine in the township of Madoc. | |
| 2. Gray silicious or fine-grained mica-slates, with an interstratified mass of about sixty-feet of yellowish-white dolomite, divided into beds by thin layers of the mica-slate, which, as well as the dolomite, often becomes conglomerate, including rounded masses of gneiss and quartzite from one to twelve inches in diameter..... | 400 |
| 3. Bluish and grayish micaceous slate, interstratified with layers of gneiss, and and occasionally holding crystals of magnetite. The whole division weathers to a rusty brown..... | 500 |
| 4. Gneissoid micaceous quartzites, banded grey and white, with a few intratified beds of silicious limestones, and, like the last division, weathering rusty brown..... | 1900 |
| 5. Grey micaceous limestone, sometimes plumbaginous, becoming in its upper portion a calc-schist, but more massive towards the base, where it is interstratified with occasional layers of diorite, and layers of a rusty-weathering quartzite like 4..... | 1000 |
| In regard to the volume thus given to this series, it may be well to remark that, though allowance has been made for numerous folds in estimating it, it may still be exaggerated by many folds that may have escaped detection. | |
| Total thickness..... | 21130 |

The geographical distribution of these rocks shews a series of north-east and south-west undulations, throwing the upper division (C) into long narrow troughs in these directions. These undulations are crossed at irregular intervals by geological elevations, which separate the ends of the troughs, and by depressions which unite the sides. The anticlinal axes of the north-east undulations, which are parallel to one another, and nearly straight, appear, as far as ascertained, to be five in number, producing six synclinals; while of the transverse elevations, one runs north of west in a

* The rocks of this division are described at some length in Mr. Macfarlane's Report on Hastings Co., 1866, page 95.

somewhat curved line, and another, if it be not a final out-crop of the rocks at the base, bears rather west of north. The effect of the two series of undulations gives to the upper division, when laid down on a map, the figure of two diverging forms furnished with long projecting points running in contrary directions, and precisely opposite to one another; to the contour of which the lower divisions, B and A, conform as will be seen on the accompanying geological map.

DIVISION A.

Lower division. Perhaps the most striking and prominent feature in the townships of Madoc and Marmora is that formed by extensive barren red syenitic rocks, which cover a large area where the two townships adjoin. Such rocks, (A 1) in which there are no apparent marks of stratification, are met with at both ends of Hog Lake, in Huntingdon, about two and a-half miles south of Madoc village, where they are immediately overlaid by the main body of the Lower Silurian limestones. On the west side of a promontory of these limestones the syenitic rocks strike northward into Madoc and Marmora, as far as the middle of the eighteenth lot on the boundary between these townships, with a breadth of about four miles, the river Moira forming their western limit, whence they spread eastward to the third range of Madoc. This mass is known as the Huckleberry rocks or Red Mountains. They are chiefly composed of flesh-red feldspar, translucent quartz, a little greenish hornblende, and sometimes finely disseminated crystals of specular iron and iron pyrites.

Red syenites
of A 1.

All through this area the country is much broken up, and hardly passable, the high barren ridges alternating with extensive swamps and marly ponds. These ridges run in a northwest and southeast direction, and the rock is in many parts overlaid by outlying patches of Lower Silurian limestone. From the northern part of this area a subordinate elevation strikes south-eastward across the fifth, sixth and seventh concessions of Madoc, having a breadth of from one and a-half to three quarters of a mile, pointing for a similar mass at Downey's rapids at the eastern end of Hog Lake. On the seventh range it is seen to pass under an outlying patch of Silurian limestone about the eighth and ninth lots, and is lost sight of. Several very extensive beds of magnetic iron ore, and deposits of red hematite occur in the immediate vicinity of this syenitic mass in Madoc and Marmora, such as the Seymour, McCallum and Marsh beds, which will be referred to further on in division B, to which they belong.

On the outskirts of the area just described, and at its junction with the overlying rocks, there occurs in many places a breccia with a granitic or feldspathic base, inclosing fragments of gneiss and greenstone or diorite,

with magnetite, as seen a short distance south of Powell's saw-mill on the river Moira, about the fourteenth lot of the tenth range of Marmora. Another similarly brecciated, but much more strongly marked mass, in some parts containing rounded fragments, crosses the Hastings road about three miles north of Madoc village, running in a south-easterly direction down the sixth and part of the seventh ranges, striking with and immediately adjoining the Seymour iron-ore bed, and forming high and broken ridges of a pale red color. The enclosed fragments are greenstone, felsite, gneiss, and translucent quartz, varying in diameter from less than one inch to eight or nine inches. Granitic breccia.

In the north-west quarter of Madoc, between the village of Bannockburn and the northeast corner of Marmora these red syenitic rocks are seen forming several connected parallel high ridges, called the Red Hills, running northeast and southwest through the influence of the undulations, whose axes bear in that direction. Here they are associated with albitic granite, the feldspar being of a pale gray, mixed more or less with translucent quartz and a considerable quantity of black or brownish mica in comparatively large scales. Red Hills, Madoc.

High barren hills of red syenite, known as the Red Mountains, are next seen in the northwest quarter of Lake township, stretching from Tongamongue Lake northeastward to Clear Lake, which is situated on the twenty-sixth and twenty-seventh lots in the eighth range of the township, the distance across being about four miles and a-half. Northeastward these hills pass a little beyond the town line of Wollaston. Red Mountains, Lake.

In Methuen township, at the western end of Trout Lake, about two miles westward of the mass last described, another north-east anticlinal bringing the syenite rocks to the surface, extends from the neighbourhood of Kah-sey-bah-gah-mog Lake, which lies between the sixth and eleventh lots of the seventh and eighth concessions of Methuen, northeastward into the south-west quarter of Wollaston, forming an area commonly known as the Pine Plains, and occupying the country for a breadth of nearly six miles, from the twentieth and twenty-first lots of the first range of this township northwestward to South Bay on Loon Lake in Chandos. Pine Plains, Methuen.

North-westward again similar rocks were seen crossing the Burleigh road into Anstruther, but here they have not yet been traced. On Stoney Lake, between the townships of Dummer and Burleigh, similar red syenitic rocks are seen, forming apparently the crown of a north-east and south-west anticlinal. This locality has been alluded to by Mr. Murray in his Report of 1852-53, and the syenitic rocks here may be a continuation of those of Kah-sey-bah-gah-mog Lake, but the relation has yet to be made out.

These successive parallel syenitic ridges between Madoc and the Bur-

Transverse
anticlinals.

leigh road in Anstruther would appear to be brought to the surface on a north-west transverse line of elevation. A second transverse axis starts from Elzevir, and, diverging from the line already described, runs somewhat westward of north through Grimsthorpe, Cashel, Dungannon, Monteagle and Herschel townships, crossing a continuation of the same north-east anticlinals as before. On this second axis of elevation, which probably brings up the whole of the rocks of division A, the following were some of the varieties observed :

Higher rocks
of A.

1. Coarse grained rock composed of flesh-red feldspar and translucent colorless quartz, the latter often in rudely parallel layers.
2. Coarse feldspathic masses, weathering to an opaque white, the constituents being white feldspar, translucent quartz and black mica in partially continuous layers, often determining the cleavage of the rock, which would be well suited for a durable building material.
3. Dark green hornblendic rock containing a considerable proportion of disseminated grains and crystals of magnetic iron ore, and probably belonging to the base of the next division (B).

The rocks on this second line of elevation have, as yet, been but little examined. In an area extending from the neighbourhood of Queensboro, on the one hand, to Mazinaw Lake in Barrie, on the other, and transversely from the vicinity of Finton in Kaladar to the north-west corner of Grimsthorpe, they appear to be very largely developed ; and it is probable that they will be kept at the surface in parallel ridges over four north-east and south-west anticlinals. It is conjectured that they will occupy the western half of Anglesea and the rough and unsurveyed township of Effingham. Their detailed distribution through Cashel, Limerick, Dungannon and Mayo has yet to be determined ; but on the Hastings road cliffs of similar rock were seen crossing it about a mile north of the York Branch of the Madawaska river in Dungannon, and rocks of the same description were traced as far as lots nine and ten in Herschel, where they form part of a ridge known as Eagle-nest cliff, presenting a perpendicular face of over 200 feet. The rocks on this second line of elevation, seem, through Dungannon, Herschel, and farther north-westward, to form the watershed between the tributaries of the Ottawa and those of the St. Lawrence. The areas underlaid by them, as well as by those of the more south-western line, present a rough barren country, little suited for cultivation, being covered by a light sandy and often shallow soil, supporting pine, hemlock and occasionally beeches, the latter usually occupying sandy ridges.

Eagle-nest cliff.

Crystalline
limestone, A 4.

Bands of red granitic and gray hornblendic gneiss are seen associated with an extensive exposure of crystalline limestone, at the village of Bridgewater in Elzevir, where they have been alluded to by Mr. Macfarlane

in his Report for 1866. They become almost immediately covered up on the south by the main body of the unconformable Lower Silurian limestone, and their relative position in this direction could not be made out.

The rocks of sub-divisions A 2, A 3 and A 4, runs northward on the eastern side of A 1 along the second line of elevation, through the adjoining townships of Elzevir and Madoc, and those of Tudor and Grimsthorpe; in the latter two townships, however, they are only sparingly represented, and again proceeding northwestward at right angles to the northeast and southwest axes, in an area extending in breadth from the southeast quarter of Madoc to the northwest quarter of Lake, and in length from Belmont Lake to the southeast quarter of Wollaston are almost entirely wanting; their position being apparently occupied by the rocks of the second division, (B) next to be described. Further to the northwest, from the northwest quarter of Lake to the Burleigh road, as far as the country has been examined on each side, A 2, A 3 and A 4 assume once more an important character.

Starting from Round Lake in the seventh concession of Belmont, an important band of crystalline limestone (A 4) has been traced continuously Limestone. northeastward across the lots to a position between Deer Lake and Lost Lake, where it turns northwestward to the thirty-first and thirty-second lots of the sixth range. It here covers a considerable area, and very much resembles the white crystalline limestones of Bridgewater in Elzevir. On the thirty-second lot an excavation on this band is known as Jones's marble quarry, from which specimens of marble were sent to the Paris Exhibition in 1855. From this the band has been traced northeastward across the southeast quarter of Methuen into Lake, as far as the fifteenth and sixteenth lots of the third concession. It then runs across the sixteenth, seventeenth, eighteenth and nineteenth lots of the second concession, into Trout Lake, but its farther distribution is not yet ascertained.

DIVISION B.

The hornblendic and pyroxenic rocks of this division, both massive and Middle division. schistose, are for the most part distributed through the counties of Hastings and Addington. They are here seen to rest immediately upon the gneisses of A 2 and A 3, but whether conformably or not is a question yet to be investigated, as in the localities where they are best represented, the massive diorites and greenstones, which form the base of this division, do not offer any clear marks of stratification.

The rocks of B are very largely represented on the second line of transverse elevation, between the townships of Madoc and Elzevir, where

they have been described in some detail by Mr. Macfarlane in his report on Hastings in 1866.

They are here much intersected by veins of a milky-white quartz, containing sulphurets of copper, and in some instances, as at the Barry mine in Elzevir, range II lot 5, native gold. From Elzevir, they trend northward on the western border of A, and again are seen covering a large part of Tudor and Grimsthorpe townships. To the northward on this line they are but sparingly represented. From Tudor they run westward into Lake, and are there very largely exposed along the first line of elevation of division A, and are often characterized by the presence of important beds of magnetic iron ore, forming a ferriferous zone. Northwestward from the township of Lake towards the Burleigh road, on this line of elevation, they gradually diminish and are lost sight of, but stretch southeastward on the same line into the township of Madoc, where, however, the ferriferous band is almost their only representative.

Iron ore belt.

The deposits of iron ore in Madoc, Marmora and Belmont, which occur in the ferriferous band at the base of the greenish hornblendic and pyroxenic rocks, have been alluded to in several of the early annual reports of the survey; they have also been noticed in the General Report on the Geology of Canada for 1868, pp. 675 and 676, and again in greater detail in Mr. Macfarlane's Report for 1866. In these various Reports, however, they have been described as separate local deposits, a sufficient number of facts not having then been accumulated to unite them in one continuous horizon. But having during the last three seasons, in accordance with your instructions, examined them more in detail, with relation to the rocks in which they are enclosed, I have been able to satisfy myself that, with one or two unimportant exceptions, nearly all the deposits of magnetic oxyd in the district will be found in the present division, being sometimes its only representative. As the deposits of iron ore already known in this zone are of economic importance, and as other yet undiscovered masses of a similar character may exist, I shall, with a view of aiding the search for them, here give a somewhat minute description of the course in which it appears to me they will be found to run.

Its distribution.

Madoc.

The Seymour ore-bed is situated on the eleventh lot of the fifth range of Madoc, where the associated hornblendic and pyroxenic rocks, and certain chloritic slates there occurring, are well displayed. Their course from this lot is about S. 65 E. (mag.), and passing through the tenth and ninth lots of the sixth range, and the eighth and seventh of the seventh range, along which course the ore is almost continuous, it becomes partially covered up by the unconformable Lower Silurian limestone; but turning over the axis of an anticlinal, it can be traced curving through the seventh, eighth and ninth lots, and part of the tenth in the eighth

range, whence it strikes N. 65—70 W. (mag.) through the tenth, eleventh and twelfth of the seventh range, and thence through the thirteenth, fourteenth and fifteenth of the fifth range. On the last named lot a deposit of magnetite occurs, perhaps next in importance only to the Seymour bed, and it is worthy of note that its place here is exactly opposite to this bed, and on the other side of the anticlinal mentioned, on the crown of which occurs a coarse red syenitic rock, (A 1) which has before been referred to.

From the seventeenth lot of the fifth range the course of the iron-bearing rocks gradually tends westerly, and would appear to pass through the seventeenth and eighteenth lots of the fourth range, the eighteenth of the third, and the eighteenth and nineteenth of the second and first ranges. On these last named lots in the first range the ore is probably again in considerable quantity, but the traces of it occur only in loose masses in the soil, the ore in place being apparently at a considerable depth beneath the surface.

From these lots the bands runs into the township of Marmora, and, Marmora. changing its direction, trends southward, keeping almost immediately to the east of the Moira River, the course of which might almost be said to denote its farther run through this township. On the nineteenth and eighteenth lots of the eleventh range this iron zone is represented by rust-stained slates, holding some considerable beds of yellow sulphuret of iron with traces of magnetic iron ore, and here it is closely associated with a large mass of coarse white granular limestone. Thence it runs southward through the tenth, ninth and eighth lots of the ninth range, where the McCallum iron-ore bed, mentioned in an early report, is situated; while farther southward its course is indicated on the sixth and seventh lots of the eighth range, by the occurrence of the Marsh ore-bed.

A short distance beyond these last lots, the ferriferous belt must run under the main body of the Silurian limestone lying to the south and to the east, where it is lost sight of. But while thus covered it appears to change its course, and bearing westward, emerges at Marmora village, where Epidotic rocks. the green hornblendic and epidotic rocks are marked by traces of magnetic iron ore, and hold veins of red hematite. These rocks are seen running into Crow Lake, under the waters of which, and under the adjoining unconformable overlying horizontal Lower Silurian limestones, the greater part of the strata of this division are concealed. The north shore of the lake, however, gives evidence of the course of the belt, in the Kean ore-bed, which occurs on the thirteenth lot of the third range of Marmora, and in an exposure protruding through the Silurian limestone on the sixth lot of the first range of this township. Belmont. The Big ore-bed, on the south shore and western extremity of the lake, in Belmont, belongs to the same belt, and is probably brought up on a third line of elevation to the west ward.

Belmont.

Northeastward through Belmont no very large exposures of the ore have yet been observed ; but deposits may still be found between Crow and Belmont Lakes, along the western shore of the latter, and up the valley of the Crow River, as well as on Deer Lake, about the twenty-fifth, the twenty-sixth and twenty-seventh lots of the second and third ranges. The exposure at Allan's mills, on the twenty-fifth lot of the twelfth concession of Seymour, noted by Mr. Murray in his Report for 1852-53, has probably some relation to the turn which occurs in the course of the belt in Belmont Lake, but whether united by a continuous out-crop, or separated on the opposite side of an anticlinal form, the overlying Silurian limestone prevents us from deciding.

Madoc.

Returning to the Seymour bed in Madoc, with the view of tracing this belt eastward, we find very few deposits of the ore of any extent. On the twelfth lot of the fourth range we have a small bed of magnetic iron ore, and again on the sixth lot of the third range, beyond which, southward, the belt runs under the Silurian. At the eastern end of Hog Lake, on the Moira River at Downey's rapids, magnetic iron ore is again met with, and finally in Elzevir, on the third lot of the fifth concession, where it occurs in a bed from two to three feet thick enclosed in a steatitic material, as mentioned by Mr. Macfarlane in the Report of 1866.

Elzevir.

Where the rocks of division B are brought up in the northwest quarter of Madoc, magnetic iron ore has been found on the twenty-fifth lot of the sixth range of Madoc, where a small bed occurs, dipping to the northeast at an angle of from forty to forty-five degrees. The only other locality is in the extension of the belt farther north, on the fifty-fifth lot, on the west side of the Hastings road, in Tudor, where it is associated with gneiss and granular limestone. (A 3 and A 4). This last locality has not been mentioned in any of the previous published annual reports, but samples of the ore were sent by you to the London Industrial Exhibition of 1862. The ore would appear to be of excellent quality, although more or less mixed with graphite. The breadth of this bed could not be determined, owing to the wood-covered condition of the country, but from the large masses of ore scattered about in the vicinity there is little doubt that it occurs in abundance.

Tudor.

It is probable that other beds of this ore will yet be found along the course of the rocks B, whose distribution has thus far been partially pointed out, and will be farther understood from the description to be given of the distribution of the next overlying division (C), at the base of which this ferriferous belt occurs. Rocks similar to B were again seen largely developed in the vicinity of Flinton, in Kaladar township, where they are on the eastern border of the second transverse line of elevation, which brings up division A. They here stretch with an apparent thickness

Kaladar.

of 3000 feet, northeastward along the Addington road, between Barrie and Anglesea, to Maxinaw Lake in the former township. Along the line they are intersected by numerous reticulating veins of a pistachio-green epidote, which divide the mass into rhomboidal forms, and altogether bear a strong likeness to the description given in the Geology of Canada, of similar diorites and slates in the Huronian system. In Addington they are also followed by a green slaty conglomerate, which at present is supposed to belong to the base of the next and highest division.

Epidiotic
diorites.

DIVISION C.

The limestones, mica-schists and calc-schists of this division are spread in a very irregular manner over the country examined. As stated on page 146, they may be said to form two series of troughs running northeast and southwest, more or less connected with each other at their sides by two transverse depressions of the strata, and separated in the middle by a transverse elevation.

Upper division.

The number of these synclinal forms is five, with an average breadth of between four or five miles each. The most southeastern one is so obscured by the interference of the overlying unconformable Lower Silurian limestone that little more can be said of it than that its axis may be considered to occur somewhere near Queensboro', in the southeast quarter of Madoc. The axis of the second synclinal runs through the southwest and northeast corners of Marmora, and through the northwest quarter of Grimsthorpe. In this form the upper division has a length of about twenty-four miles from Crow Lake northeastward, and is divided into two parts of nearly equal length, which are separated from one another about a mile and a-half at the northwestern extremity of the Red Hills. The axis of the third would pass through the united corners of Belmont Lake and the centre of Cashel. In it the upper division stretches for about thirty miles northeast from Belmont Lake, and is separated, as in the last, into two nearly equal portions about a mile and a-half apart on Beaver Creek, about two miles below the bridge on the Hastings road. This synclinal is affected by minor northeast undulations, sufficiently prominent to divide it longitudinally into several subordinate forms. The fourth axis runs through the adjoining corners of Methuen and Wollaston, and across the middle of the south line of Dungannon. In it the rocks of the upper division have an extent of fifteen miles southwestward to Eagle Lake, where the summit of the underlying division B appears, but what separation there may be between this and a basin on the same axis farther to the southwest, has not been clearly made out. The axis of the fifth

Five synclinals.

Second basin.

Third basin.

Fourth basin.

Fifth basin.

synclinal runs through the adjoining corners of Burleigh and Chandos, and those of Dungannon and Carlow. The rocks of the upper division in this extend from the York Branch of the Madawaska River, for about thirty miles to the south-western end of Loon Lake in Chandos. This form is, like all the others, probably divided into two parts by the out-crop of rocks of the lower divisions (A and B) somewhere in the northwest quarter of Wollaston.

The different rock masses which fill these troughs, have already been given in the general section, and I shall now proceed to give some few local details in regard to their distribution, beginning with the lowest, (C 1).

Limestones, C 1.

At the base of the third division we have in many places large exposures of crystalline limestone, associated with dolomite. A white crystalline limestone of this horizon is very largely represented in the first synclinal in Elzevir, at the village of Bridgewater, and it has there been quarried for building purposes and used in Belleville. Westward from this the same band covers a large part of the fourteenth lot of the fourteenth range of Huntingdon, on the shore of Hog Lake, where it has been worked, and would appear suitable for constructions. It is, however, on this lot much more interstratified with white quartz, tremolite, and an impure talc-slate, all of them in thin layers, and it holds a bed of translucent quartz five feet thick. The layers of tremolite weather out in relief from the surface of the limestone and give a ribanded appearance to the rock. On this lot, near the shore of the lake, there is a considerable exposure of pale flesh-red somewhat magnesian limestone, weathering to a yellowish-drab, together with a brown-weathering dolomite cut by minute seams of magnetic oxyd of iron, which weather out into sharp edges on the surface. The flesh-red limestone, being of a compact texture, appears well suited for ornamental purposes; but both it and the dolomite are more or less micaceous, and often much interstratified with greenish dioritic slates. From this lot these bands run into Hog Lake, but are again seen about the middle of it, forming a large part of the Bridge Island.

Dolomites.

Immediately to the east of the village of Madoc, bluish and bluish-gray banded crystalline limestone belonging to this horizon (C 1) adjoins a drab or brownish-yellow dolomite. The limestone is more micaceous than in the previous locality, and the mica, being in continuous layers, at irregular distances through the mass, in most instances indicates the bedding of the rock. This limestone has been worked and used in Belleville, but does not furnish a very good building stone.

On the seventeenth lot of the sixth concession of Madoc, at and around the Desperado mine, in the vicinity of El Dorado, a beautiful compact pale flesh-red very silicious dolomite occurs, and extends east and west into the neighboring lots. On the eighteenth lot of the fifth range, on which

is situated the Richardson gold mine, the dolomite forms prominent ridges much interstratified with silicious slates.

On the line between the first and second synclinal, in the twenty-fifth and twenty-sixth lots of the sixth and seventh ranges, is a limestone of a bluish-white, which would appear well suited for building purposes; but no openings have yet been made on it in this locality. Limestone.

Yellowish-drab dolomites of a compact texture are seen on the east side of the Hastings road, in the twenty-second, twenty-third and twenty-fourth lots of the sixth range of Madoc, whence they strike in a northwesterly direction into the township of Lake.

On the road running between the seventh and eight ranges of Madoc, in the fourteenth and fifteenth lots, ridges of a beautiful pinkish-white dolomite occur. It is of a rather compact texture, and appears to be very silicious, yielding much fine white sand in weathering. Veins of white translucent quartz cut this mass in many directions, holding occasional traces of copper pyrites.

On the south-east side of the second synclinal, on the sixteenth lot of the eleventh range of Marmora, and extending into Madoc, there occurs a large area of white granular limestone which, when examined in 1866, was being quarried by a marble-cutter named Feigel. This marble seemed to work well, judging from the finished samples shewn me, and might be used for ornamental purposes. In accordance with your instructions samples of this stone were prepared and forwarded to the Paris Exhibition of 1867. Marble.

In the third synclinal, at the south-western end of the north-eastern portion, a very fine grained white limestone was met with on the fifty-fifth lot, west side of the Hastings road, in Tudor, immediately adjoining the magnetic iron ore alluded to when describing the distribution of the ferri-ferous belt.

Overlying the limestones and dolomites (C 1) of this part of the upper division there occurs a series of mica-slates (C 2) grayish and sometimes greenish in color. Lighter and darker shades among these appear to be due to varying proportions of mica and in some cases of hornblende. Mica-slates, C 2.

The limestones and dolomites (C 1) appear to be wanting in some places, and in this case the mica-slates (C 2) rest upon the rocks of division B. It is then also somewhat difficult to define the line of separation between the two, particularly when the mica-slates assume a greenish color, and the limit has, in such cases, to be somewhat arbitrarily assumed.

The mica-slates of sub-divisions C 2 and C 3, are extensively developed in the south-eastern side of the first or Madoc synclinal, where they have been described, together with the rocks of division B, by Mr. Macfarlane

Mica-slates.

in his Report for 1866. From Madoc they pass into the second synclinal, and in it are seen along the southern half of the eastern side of Tudor, and the western of Grimsthorpe.

Bannockburn.

In their course along the north-west side of the synclinal, these slates are seen through the eastern portion of Lake, and southward to Bannockburn village, in Madoc township, in which last locality the rusty-weathering quartzites of the following sub-division, C 4, make their appearance, and together with the rusty mica-slates of C 3 predominate, almost to the exclusion of C 2. From thence they were traced southward, as far as Keller's bridge over the Moira river, on the Hastings road, where they were overlaid by a patch of the Lower Silurian limestones.

In Marmora, in the southern portion of this second synclinal, the slates of C 2 and C 3 are seen covering a considerable area on its north-western side, from the north-east quarter of that township to the foot or southern extremity of Belmont lake, in Belmont township; and thence along the south-eastern side of the same synclinal through Crow lake, in Marmora, beyond which they are concealed by the overlying Lower Silurian limestones.

In the third synclinal, namely that passing though Belmont and Lake townships, these slates are very largely represented in its southern part; they are seen along its north-western side through the south-east quarter of Methuen and the southwest of Lake, and form prominent ridges near the bridge over Deer river, in the twelfth and thirteenth lots of the third range of Lake township. In the last locality they strike nearly north, with a dip to the eastward of somewhat less than thirty degrees, and are here seen to rest upon the gneisses of division A.

Further on in their course, these slates reach Burnt lake, which occupies the seventeenth and eighteenth lots of the seventh, and the greater parts of the same numbered lots of the sixth range, where islands composed of these slates mark the run of the band through the lake, and belong to the northern extremity of the southern portion of the third synclinal.

At the south-western end of the northern portion of the same synclinal, slates of divisions C 2 and C 3 are seen to spread over a considerable area in the vicinity of Dickey and Clear lakes, where the prevailing color of the rocks is gray. On the southeastern side of this part of the synclinal, these slates from the chief rock on the east side of Wadsworth lake, situated in the north-east corner of Tudor, whence they run into Cashel, with a steep dip to the north-west. On the north-western side of this third synclinal these slates of divisions C 2 and C 3 are but sparingly represented, and continue to be so in the two remaining synclinals to the north-westward.

In the first or Madoc synclinal, at its southern extremity, on the farms

of O'Hara and McKenzie, lots three, four and five of the fifth range, the slates of C 2 are bluish, fine grained, and somewhat argillaceous, but with a cleavage however parallel with the stratification. These have been somewhat extensively quarried, and cut for whetstones, and are referred to in the *Geology of Canada*, pp. 66, 809. Further specimens of these slates were procured by myself during 1866, samples of which, cut and prepared in Montreal by an experienced person, were pronounced to be very suitable for whetstones. This variety has not yet been met with in any of the other synclinals to the northward. Whetstones.

In different parts of the vertical thickness of the slates of C 2 and C 3, and in many places in their distribution, occur three different descriptions of conglomerate, all of which are seen on the lots just mentioned, where they occur in the following order, ascending :

- I. A dolomite much interstratified with dark silicious mica-slates, both often holding large and well-rounded masses of quartz and syenite, which vary in diameter from one to twelve inches. Conglomerates.
- II. A black and very silicious slate holding large boulders of gneiss and syenite, and forming smooth rounded dome-like ridges.
- III. A grayish and sometimes greenish mica-slate, having small flat oval pebbles of vitreous quartz lying on their sides in the planes of bedding.

It may be remarked that while the last conglomerate is the highest in the series, it is also the most continuous of the three ; the other two coarser conglomerates appear to occur in lenticular patches of a more local character. At the village of Bridgewater conglomerate layers abound in a band of mica-schist 120 feet thick, having a streaked surface from the alternation of grayish and reddish layers. The enclosed pebbles are of red and white quartz, occurring in parallel beds from two inches to five feet in thickness, which are separated by mica-schist layers holding only a few scattered pebbles.

Westward from this a similar band of conglomerate is seen on the north side of the road leading from Bridgewater to Madoc, on the third lot of the eighth and ninth ranges of Elzevir, which appears to me to be a continuation of that of Bridgewater. Here, however, it is associated with one of the coarser conglomerate bands (II) rising in large rounded ridges from the field. The matrix appears to be chiefly a black silicious slate, and it is more or less charged with well-rounded fragments of quartz and syenite. Adjoining this, but below it, there occurs a conglomerate with a schistose dolomitic matrix, the pebbles themselves sometimes being of dolomite, interstratified with similar black silicious slates. In some places the rounded fragments once enclosed have been removed from the exterior, giving to the surface of the mass a pitted and cellular appearance. Where these rounded masses are enclosed in the greatest abundance they lie in

the form of parallel beds or lenticular patches, the portion between these beds holding only a few scattered pebbles.

These conglomerates in the first synclinal are lost sight of for some distance under the horizontal Silurian limestones, but are again seen immediately to the north of the village of Madoc, forming a conglomerate ridge described in the *Geology of Canada*, p. 32. The matrix of this is a mica-slate more or less charged with grains of a dark green steatitic mineral. The enclosed fragments are in general rather angular, and of white and black colors. Similar conglomerates occur on the third, fourth and fifth lots of the fifth range of Madoc, where they are on the north-western side of the first or Madoc synclinal.

In the third synclinal, on the north-west side, conglomerates are seen associated with slates, and forming several islands, running with the strike, on Belmont Lake, where they have already been described in Mr. Murray's Report for 1852-3. They dip to the east or south of east, and are similar in character to those above mentioned.

The lower members of the upper division, thus far described, (C 1, C 2 and C 3) constitute, in their distribution, the rim of the two sets of troughs into which the five synclinals of the district have been divided. The centres of these troughs are filled with the calcareous and quartzose beds which correspond to the higher members of the upper division. Later observations make it probable that the thickness of 1900 feet assigned in Madoc to the quartzites C 4, is an exaggeration, since in the second and third synclinals these quartzites are much less conspicuous, and cannot be distinguished from certain quartzose beds which appear to be interstratified with the calcareous strata of C 5. This subdivision presents many varieties of rock, some of which are repeated several times in the vertical thickness. The strata, however, are corrugated by numerous minor undulations, which often give repetitions of the variety of a special horizon, on a given line of section. It hence becomes impossible to give the sequence of these varieties, which I shall therefore describe in the order of their importance as seen in the township of Tudor, where they are as follows :—

Division C 5.

Varieties of
C 5.

1. Gray micaceous limestones or calcareous mica schists, somewhat plumbaginous, with *Eozoon Canadense*.
2. White and bluish-gray compact limestone, slightly silicious.
3. Grayish quartzite weathering to whitish and yellowish-brown, and shewing these colors in alternate bands on weathered surfaces.
4. Gray impure sandy limestones with a pitted weather-worn surface, streaked and spotted with ferruginous stains.
5. Gray impure limestone, similar to the last, but in addition holding radiating concretionary forms of a greenish-black hornblende, the latter weathering out in rusty sub-globular masses, which are scattered irregularly through the rock, and vary in size from one quarter of an inch to one inch in diameter. This band seldom exceeds six feet in thickness.
6. Small interstratified bands of diorite or diabase, chiefly seen towards the base of the sub-division C 5.

Their distribution has been sufficiently pointed out in describing the slates C 2 and C 3, which, as before stated, form the rim of the troughs occupied by the higher rocks. It should be mentioned, however, that in passing north-ward from the second to the fifth synclinal, in Hastings, the slates and limestones of the subdivisions C 2—C 5, gradually diminish in amount, and only the beds of C 1 are observed in the fifth synclinal.

The schistose and plumbaginous limestones of C 5 are characterized by the occurrence of the fossil rhizopod described by Dr. Dawson under the name *Eozoon Canadense*. Unlike the specimens of this fossil found in the crystalline Laurentian limestones at several localities on the Ottawa, in which the calcareous skeleton is generally filled with serpentine or some related silicated mineral, the *Eozoon* from this region is imbedded in an impure earthy dark gray limestone, with which and with carbonaceous matter, the cavities in the white calcareous skeleton are filled. Fragments of *Eozoon* from this sub-division, were first detected by Dr. Dawson from an unknown locality in Madoc, but numerous specimens of the fossil have since been found on the fifteenth lot of the range east of the Hastings road, in Tudor. The specimens from this region like those from the Calumet on the Ottawa, are small isolated imbedded masses, unconnected apparently with any continuous reef such as exists at Grenville and the Petite Nation.

Eozoon Canadense.

Specimens of the *Eozoon* from Tudor and Madoc have been described and figured in a series of papers read before the Geological Society of London, by yourself and Drs. Dawson and Carpenter; published in the *Quar. Jour. Geol. Society* of London, for August, 1867, and reprinted in the *Canadian Naturalist*, vol. iii, No. 4.

In conclusion, I would state that, with a view of determining the further spread of the rocks of division C, explorations were carried on northward from the York branch of the Madawaska river, between the townships of Montegale and Herschel, as far as the Peterson road; thence eastward along that road through Wicklow, Bangor, Radcliffe and Brudenel, to the Opeonga road; and south-eastward through Sebastopol and Grattan to Renfrew village on the Bonnechère river, but without discovering a repetition of these higher rocks. The whole tract of country thus explored is composed of rocks similar to those of division A of the general section.

LOWER SILURIAN LIMESTONES.

To the north of the great area of Lower Silurian limestones of the Trenton group, whose limit was described by Mr. Murray in his Report for 1852-3, we find isolated, or island-like patches of these limestones for

GEOLOGICAL SURVEY OF CANADA.

distance northward in the townships of Madoc and Marmora, and separated by some miles of country occupied by the older rocks—these patches of limestone, about one mile in length by one-half width, occurs as far north as lots five, six and seven on the line of the townships of Lake and Methuen, ten miles distant from the edge of the main Silurian area, where it forms a tract of good land as the Van Senkler settlement.

Though Madoc and Marmora there occur similar but more extensive fields of these limestones, which are shown on the map accompanying the Report, and were described by Mr. Murray in his Report already published. These Silurian islands almost invariably present a precipitous front to the north, the strata dipping at a very slight angle southward, and the surface being covered by a deep soil, their ruins stretching far to the limit of the limestones themselves, and forming rich and fertile fields. Throughout Madoc the chief settlements are in the vicinity of the limestone islands, and are often separated from one another by tracts of land, barren and unfit for cultivation.

Where these limestone have been denuded, their surface is seen covered with numerous grooves or markings, the general trend of which is from north to south, or east of north, the same strike being also observed in grooves in an exposure of red syenite crossing the Hastings road to the north of the village of Madoc.

ECONOMIC MINERALS.

The economic minerals of the district under examination, as known up to the present, were the ores of iron, lead, copper and antimony, with whetstone, lithographic stone, building stones and limestones, to which are to be added ores of bismuth and silver, and also native gold.

Magnetic and Hematitic iron ores.—The ores of iron, both magnetic and hematitic, occurring in Hastings county have been mentioned in several of my Annual Reports, as well as in the Geology of Canada, and having been the special subjects of Mr. Macfarlane's Report so recently as 1866, I have little to add to what has heretofore been said about them.* The distribution of the ferriferous band, in which all the magnetic ores are included, is no doubt a matter of economic value, but this, as far as I have been able to trace it, has been given in that part of the Report which is devoted to geological structure, page 150. All that I have to state therefore

giving the localities of iron ores in that report the two following typographical errors occur: page 100, 9th line from the bottom, "the ninth lot of range six," should be "the sixth lot of range nine,"; page 102, 16th line from the bottom, "Madoc" should be "Marmora."

will be little more than a few facts respecting new openings in the Big ore bed of magnetic oxyd on Crow Lake.

Although the lower part of this ore bed had been previously tried, little of that part had been excavated. In 1867 a company, composed of gentlemen from the United States, was established for the purpose of working ore from the bed, with a view to its being smelted. After trials of several parts of the band that near the base was found to be of suitable purity, and during that year 300 men were employed in mining and sorting the ore, of which, towards the end of the season, 150 tons a-day were being carried away from the locality by rail, and shipped at Cobourg. A few hundred yards south-east from the main work another excavation was made upon what is called the Sand-pit bed, supposed to be still in the band, from which a purer ore was obtained. The ore from both excavations was sorted into three qualities, of which Nos. 1 and 2 were selected for exportation, while No. 3 was left on the ground for future disposal.

In Mr. Macfarlane's Report for 1866 mention is made of the specular ore of iron occurring on the second lot of the fourth range of Elzevir. This deposit was opened during my stay in Bridgewater in 1867, but the ore was not found to exist in remunerative quantity. Mr. Macfarlane makes mention of the occurrence of hematite in a ploughed field, in and around a depression on the east half of the twelfth lot of the fifth range of Madoc, where the appearances were such that, although assured no mining had been done there within the memory of the oldest inhabitant, he could not resist thinking that the depression was all that remained of an open work from which much ore had possibly been raised and removed. This lot, I understand, is the property of Messrs. T. C. Wallbridge & Brothers; but Mr. D. L. Cumming informed me that the lot was cleared of its timber by him in 1831, when there were but thirty families in the township. He assured me also that the depression existed then as it does now, while the trees of the forest were still growing in and around it; that he was the first person to see and report the occurrence of this apparently rich deposit of hematite, and that since then eight tons extracted by him, and sent to Three Rivers to be smelted, was the whole quantity of the ore that had been removed from the place.

The ore appears to occur in loose masses, ranging in weight from one to a hundred pounds, and there seem to be no boulders of other rocks mingled with them. I was informed, however, that a large pair of antlers of some species of deer had been found imbedded in the ferruginous soil. Not only this but other deposits of hematite in Madoc and the neighboring township appear to occur in depressions in the gneiss, filled with loose masses of the ore, the geological horizon of which seems as yet to be very uncertain.

Veins of specular hematitic ore are found cutting the chloritic slates of

the ferriferous belt, as along the west side of Belmont Lake, and more particularly on the eighth lot of the fifth concession of Belmont township. The ore in these veins, however, is but of minor importance.

Galena.

Galena.—Most of the localities known as affording galena have been noticed in Mr. Macfarlane's Report for 1866, but during my explorations in Tudor, having visited all the lead-bearing lodes, openings were found to have been made in some of which the localities only had been previously indicated, and one or two were in a better condition for inspection than at the time of Mr. Macfarlane's visit.

Tudor.

One of these, on the twenty-eighth lot of range B in Tudor is a vertical vein running N. 70° W*, the strata of calc-schist dipping $274^{\circ} > 76^{\circ}$. At the time of Mr. Macfarlane's visit a shaft, which had been sunk on it to the depth of thirty-seven feet, was half full of water, preventing him from doing more than to state the information he had received from others. In 1867, I found that the lode, of which the veinstone is barytes and calc-spar, had yielded on the average three quarters of an inch of galena; but the bottom of the shaft showed no more than half an inch of barytes, without galena. I was informed by Mr. W. Kesterman, of Belleville, then superintending the mine, that there had been extracted from the vein about six tons of galena, four and a-quarter tons of which were sent to New York for sale, after being simply crushed, and found to yield 66 per cent of lead.

On the thirty-first and thirty-second lots of the range east of the Hastings road, in Tudor, a lead-bearing vein runs in a vertical attitude N. 57° W., cutting the gray calc-schists with strike N. E. E. In 1867 it had been traced, in the direction given, across both the lots mentioned, with very good surface indications, and was known as the Murphy mine. The Hastings Lead-mining Company subsequently sunk a shaft on it, which, I understand, has been carried down to a depth of 125 feet, but the result being unsatisfactory, the work was abandoned.

On the twenty-eighth and twenty-ninth lots of the fourteenth range of Tudor there is a vein of red and white heavy-spar, holding galena, and cutting the gray calc-schists. Its bearing is N. 5° E., and it stands in a vertical attitude, while the enclosing rock, also vertical, strikes almost due north and south. It was discovered some eight years ago, and was first opened in 1859. In 1867 the mine was leased by Messrs. Lombard & Co., of Boston, who were working it at the time of my exploration in Tudor, and I had an opportunity of examining the shaft when free from water. The walls were regular and well defined, the width between them being in some parts from eighteen inches to two feet, and the ore appeared in scattered and irregular bunches in the gangue. When first opened this

* The bearings in these descriptions are magnetic, the variation at Madoc being 5° West.

vein yielded some large masses of ore, but, as in a previously mentioned instance, they greatly diminished, descending, and at the bottom of the shaft, which was twenty-five feet deep, there was scarcely any ore. In 1868, at the depth of forty-two feet, the mine was abandoned. It may be remarked that many of these veins in Tudor, yielding considerable bunches of ore near the surface, shew little more than traces of galena at the depth of a few feet. Of twenty-five localities in Tudor in which galena was discovered and partially worked, but one, the Murphy mine, continued to be worked in 1868.

The west half of the tenth lot of the eleventh range of Lake is another Lake. of the localities mentioned by Mr. Macfarlane. On this lot, which was some time since bought by Messrs. Gillum & Kesterman of Belleville, occurs the Donahue vein, striking N. 50° W., and standing in a vertical attitude. Little however has here been done, and although the lode has a width in some parts of from twenty to twenty-four inches, bounded by regular walls of gray calc-schist, the galena occurs only in scattered and irregular patches and inconsiderable quantity.

On the eighth lot of the eleventh range of Lake (or possibly in the tenth range) a vertical vein, holding galena in a gangue of heavy-spar, runs through the calc-schists in the direction N. 45°—50° W. The lode varies in thickness from ten to eighteen inches, and is bounded by well defined walls. Little had been done on this lot up to 1867, but in the short distance then uncovered, I saw extracted some masses of ore at the depth of three feet from the surface, which weighed from fifteen to forty pounds, and I was informed that when first discovered much larger masses had been taken from the vein. The lode is supposed to be on the property of Mr. Wm. Sweeny of Tudor, but in consequence of the defective manner in which the township has been surveyed there at present exists a dispute as to the ownership of the lot.

The lead-bearing veins just noted I believe to be the most important in Tudor and Lake, so far as examined. In these townships there appear to be two distinct sets of these veins; one of them running north-west, and the other north-east by north, those in the former direction being the more numerous. Where such veins cross one another there appears in general a fair show of ore at the surface, which, however, as in other cases, often diminishes at the depth of a few feet. Two sets of veins.

There occurs a north-west and south-east lode near the south-east corner of Methuen, where, in 1868, a shaft was being sunk by Messrs. Parker & Baker. On this lode two or more shafts have been opened on the eastern edge of the second lot of the first range, close to the boundary line of Lake. The lode cuts gray vertical calc-schist, striking N. 20° E., and is composed of calcspar and heavy spar, the former being of a rose or flesh-red color, in Methuen.

which there is a good shew of galena. The average width of the lode is about eighteen inches, and it has been traced in a south-easterly direction for nearly three miles into Marmora.

Elzevir.

All of the lodes above mentioned, as well as all those noticed by Mr. Macfarlane in his Report of 1866, intersect the calc-schists (C 5) ; but it is not to be supposed that this is the only rock in which they occur, as it has been shewn that in parts of the country to the east, lead veins parallel to those of Hastings, and no doubt of the same system, cut not only the gneisses and crystalline limestones corresponding to division A (as for example the Frontenac mine described below,) but run up into the unconformable Lower Silurian, as far at least as the Calciferous formation. It is not surprising, therefore, to find on the eighteenth lot of the first range of Elzevir a lead-bearing lode running N. E., and intersecting the diorites of the middle division (B). The gangue of this lode consists of quartz, which, in a breadth of three feet, exposed in an opening which had been made, appeared to be much mixed with fragments of wall rock. The galena is scattered through the gangue in small, irregular but somewhat abundant bunches, in which the crystals are smaller than is usual in the lodes of other parts of the district. At the time of my visit, which was not long after the discovery of the lode, but a small quantity of ore had been taken out. On the authority of assays made by Dr. Girdwood of Montreal, and Mr. J. T. Bell of Belleville, the galena is said to hold a considerable but variable quantity of silver.

Loughborough.

Frontenac Lead Mine.—In connection with my examinations of the lead deposits of the Hastings region I visited the Frontenac mine in the rear of Kingston. The mine is situated on the south half of lot sixteen in the ninth concession of Loughborough. The rock of the country consists of grayish and reddish gneiss, interstratified with thick bands of crystalline limestone, all striking N. N. E. and S. S. W., and dipping to the westward at a high angle. The vein cuts these various bands at right angles, having a course about N. 75° W., or N. 70° W. (mag). The portion worked has a slight underlie to the north, at the surface, but becomes vertical at a depth of sixty feet in the main shaft.

Frontenac
Lead mine.

From this shaft an adit has been run about 400 feet west and 50 feet east. The average width of the vein appears to be about ten feet, although at the main shaft it varies from thirteen to nineteen feet. The veinstone, which consists of calcspar only, is arranged in bands, more or less coarsely crystalline, and sometimes of a purplish or lilac color. The only other minerals observed were very small quantities of iron and copper pyrites and blende. The galena is diffused in crystals and bunches throughout the whole vein, but appears to be most abundant towards the north wall. It

also appeared to have a disposition to run in *shoots*, having a western slope of about 45° . Between one and two thousand tons of ore had been mined. This had been sampled and portions of it assayed mechanically by Dr. Dawson, Professor Chapman and others, the mean of whose results gave from 12 to 15 per cent. of galena. A crushing mill, with washing machinery, and a smelting furnace have been erected. A quantity of the undressed ore has been crushed in this mill, and about five per cent. of galena obtained from the whole, but the work appears to have been very imperfectly performed. The pig lead produced is of an excellent quality. Professor Chapman's assays shew that it contains an average of about four ounces of silver to the ton of galena.

The vein may be traced by a series of dry depressions in the surface, or sink-holes, almost continuously for a distance of one mile to the eastward, the breadth somewhat diminishing, but the vein has still the same characters, and is in some parts rich in galena. On the eighteenth lot in the eighth concession a second vein runs parallel to the first, at a distance of about one hundred yards to the north of it. This second vein appears to be from three to six feet in width, and shews galena wherever it has been opened. It carries also a little barytes, which has not been found in the main vein. Smaller parallel lead-bearing veins have been discovered on the adjoining lots to the north. The main vein is reported to have been met with (still carrying galena) on one of the lots west of that on which it is worked.

Gold.—In the early part of August, 1866, while exploring in the neighborhood of Bannockburn village, in the township of Madoc, I was informed that a metal, suspected to be gold, had just been taken from an opening in the eighteenth lot of the fifth range of the township, on the property of Mr. J. Richardson. A visit was at once made to the locality, and the lot was found to be the same as that on which openings had previously been made for copper ore, described in Mr. Macfarlane's Report of 1866, (p. 106.) Mr. Richardson informed me that a person named Powell, and an old Dutch miner, had lately found flakes of yellow metal resembling copper, which he could beat out into thin leaves. At my request he shewed me the specimens which he had collected, and I at once informed him that the metal was gold.

The opening from which it had been taken was on the east end of the lot, the copper veins being near the south-west corner; and in it an irregular layer of chloritic and epidotic gneiss was overlaid by a silicious ferruginous dolomite, and underlaid by a band resembling an impure steatite, the whole dipping $N. 5^{\circ} E. < 45^{\circ}$. The seat of the gold appeared to be a crevice of longitudinal ovoid form, about four feet below the surface, which was filled with reddish-brown ferruginous earth, in which were scattered

fragments of a black carbonaceous matter, the latter shewing, when broken, small flakes or scales of the metal. The crevice seemed to be in the schist, at its junction with the dolomite, and presented an attitude conformable with the stratification. This I believe to have been the earliest discovery of the metal, and samples were procured and sent to the Geological Survey office long before any reports were generally circulated as to its existence in the township. Having remained in the vicinity of the opening for a few days while some fresh blasts were made, and seeing no farther development of the precious metal, my general exploration was continued.

Richardson
mine.

Early in October, however, information was brought to me that farther discoveries of gold had been made on the Richardson lot, and returning, I found that at the depth of fifteen feet another open crevice had been struck, which, beyond doubt, had proved rich in the metal. By permission of Mr. Richardson I examined the opening, and took such samples for assay as were thought proper. The shaft, to the depth of fifteen feet, with a transverse measure of about seven feet, had been sunk the whole way on the slope of the strata, which were of the same character as those already described. The chloritic and epidotic gneiss appeared to be much intermingled with calcspar and bitter-spar, which ran in short lenticular interlocking patches, each an inch or so thick, in a total width of about eighteen inches at right angles to the stratification, and in place of them there were occasionally small openings partially filled with the ferruginous earth, in several of which gold was detected. The opening at the bottom, which was of a nearly circular shape on the plane of the bed, and about eighteen inches across the stratification, appeared to include the whole thickness of the band holding the smaller dolomitic patches and cavities above. It was partially filled with the same brown ferruginous earth as before mentioned, with which black carbonaceous matter was much intermingled. In some parts of the opening this black substance appeared to adhere to the chloritic schist, and in others to the dolomite.

From this opening* I extracted about three pints (by measure) of the ferruginous carbonaceous earth, and the following were the results of some very rude experiments tried on the spot. Taking a pint of the earth, just as it came from the opening, it was reduced by washing to one-half its bulk, and when dry the residue was pulverized. Spreading the latter in a shallow tray the lighter substances were removed by continued shaking and gentle blowing, and there remained a dark colored gold dust, in which were a few angular fragments weighing from one to three-and-a-half grains each. The whole of this dust weighed fifteen pennyweights; but there can be little doubt that by the rough method used a considerable amount must have been lost. In a second experiment two-and-a-half

* Now known as the Phoenix Mine, 1870.

pints gathered by me, yielded, by a rude washing and amalgamation, twenty-six pennyweights of pure gold. Rough as these experiments were, they afforded sufficient proof of the unusual richness of the deposit. At this time no trace of the metal was observed in the enclosing rock, but shortly afterwards some very beautiful and rich specimens from the same opening were shewn me, in which the gold was enclosed in the dolomite and calcspar.

Shortly after the examination just alluded to, in consequence of disputes connected with the mine, the shaft was closed up, and no farther examination was permitted. On the arrival, however, of Mr. Michel on behalf of the Geological Survey, some weeks later, he with difficulty obtained a hurried view of the opening, and the results of his observations subsequently appeared in a Report addressed to you on the 29th January, 1867.

The seat of the gold in the Richardson Mine does not appear to me to be a true vein, but simply a series of crevices or openings in a gold-bearing bed, formed of chloritic and epidotic gneiss holding patches of dolomite and calcspar, the openings being nothing more than such as are so often met with in the dolomites and calc-schists of this region as almost to entitle them to the appellation of cavernous. Thinking it therefore possible that the gold of the Richardson Mine might be confined to a special horizon, I proceeded to trace out the rocks at the junction of which it occurs on the Richardson lot, and it may now be stated that some recent and reliable discoveries made during the season of 1868 seem to make this conjecture probable.

The rocks of the Richardson lot are exactly similar to those which have been described as running though the farms of O'Hara and McKenzie in the fifth range of Madoc, which are, however, on the opposite side of an anticlinal, and the seat of the gold seems to be at the junction of the mica-slates (C 2) and the dolomites (C 1) of the section there described. This position would be at no great distance above the ferri-ferous band, and the course of that band, as already given, may thus become a guide not only in the search for iron, but for that of gold also.

In Elzevir, Madoc, Marmora, Lake and Tudor the number of localities in which openings have been made in the rock by prospectors in search of gold are too numerous to be mentioned. It would, perhaps, be too much to say that every lot had been tried, but it appears to me that the exceptions, particularly in Marmora and Madoc, cannot be very many. Of these localities I may say that I have visited all in which gold was reported to have been found, particularly when it was understood that an excavation of some depth had been made, and the work was still in progress. In some cases admission to the excavation was refused to me, and in others, in consequence of disputes in regard to ownership, excavations have been

Trials for gold.

filled up to prevent access by the public. A large number of specimens, however, have been brought to the Survey office for analysis, but all those localities in which, up to the present time, the occurrence of gold has been verified, appear to have the same relation to the ferriferous belt, and to be geologically above it, but never at a great distance.

Localities of
gold.

The localities on which I would rely as supporting this view are included in the following list, in all of which the occurrence of gold, in greater or less quantity, has been verified :

Marmora,	range	IX	lot	6	Gold in quartz holding iron pyrites and mispickel, and interstratified in a silicious dolomite, sometimes in association also with chlorite-schist.
"	"	"	"	7 & 8	" " " "
"	"	VIII	"	6	" " " "
"	"	VIII	"	8	" " " "
"	"	VIII	"	9	" " " "
The gold in these four lots stands in the same stratigraphical place in relation to the Marsh iron ore bed, which is on the fifth lot of the ninth range of Marmora, and thence strikes northward parallel with the gold-bearing rock.					
"	"	X	"	15	Gold in quartz and sulphurets scattered through a silicious dolomite, and sometimes in connection with an interstratified chloritic schist.
"	"	X	"	16	" " " "
"	"	XI	"	15	" " " "
"	"	XI	"	16	" " " "
On this lot is situated the Feigel mine, and the gold in it and the preceding lots is in the same stratigraphical place as before.					
Madoc	"	IV	"	18	Gold in cavities with ferruginous earth and carbonaceous matter resulting from the decomposition of small interposed layers or irregular veins of bitter-spar, etc., between layers of chloritic and epidotic gneiss, and also of dolomite, in which latter rock also gold is sometimes seen.
"	"	V	"	18	Gold in the same conditions as before. This is the Richardson mine, and in this and the previous locality the stratigraphical place of the gold is in the same relation to the iron ore of the seventeenth lot of the fifth range of Madoc as it was to the Marsh iron ore in the previous instances.
"	"	VI	"	1	Gold in antimonial gray copper ore forming small veins with calcspar, bitter-spar and quartz in a brown-weathering dolomite belonging to the same band as before, and associated with chloritic and epidotic gneiss. This is the Empire mine, occurring in the village of Madoc.

Hungerford, range XIV lot 9 Gold in traces in antimonial gray copper ore occurring in nests with quartz, in white and pinkish crystalline limestone, which is associated with dolomites supposed to be on the same horizon as the dolomite above the ferriferous band.*

These various localities seem to have a pretty uniform relation to the ferriferous belt, and the existence of gold is reported in many other localities on the same geological horizon. I have little doubt that it occurs in many of them, but have not yet been able to verify its presence in them by my own observation. I must refrain, therefore, from doing more than refer to the general course of the iron-bearing band, which has already been indicated, a close proximity to the summit of which will, in my opinion, afford the most probable positions for the discovery of gold.

A number of specimens from openings reputed to yield gold were collected for assay in various parts of the county of Hastings, and I give, in conclusion, the results of their assay by Dr. Hunt, the method employed being the same as that described by him in his Report for 1866, p. 80, and the amount of ore treated in each case 100 grammes (1543 grains).†

* In addition to the localities cited above, gold is mentioned by Mr. Michel as occurring on the second lot of the fifteenth range of Elzevir, and I have myself, since the date of this Report, found small quantities of gold by assay in specimens brought by me from the second and third lots of the fourth range of the same township. The rock in latter locality is a mixture of quartz and carbonate of lime, holding bunches of the gray and pyritous sulphurets of copper, and it appears to be an interstratified bed, very similar to that above mentioned in Hungerford.

† The following assays were made by Prof. Jas. T. Bell, of Albert College, Belleville, and are given as confirming of the great richness of the ore from the Empire mine:—

Madoc village, range V., lot 2.—Shaft, Empire mine; antimonial gray copper; three assays by five yielded respectively per ton, of gold and silver united, \$483, \$492, \$497.

Mr. Bell informed me that during the month of May, 1868, he visited this mine and selected samples, of which the following are assays:—

Two pounds were submitted to amalgamation, and free gold was obtained at the rate of \$1.35 to the ton. The concentrated sulphides (one ounce) were smelted, and one grain of silver and 0.034 grains of gold were obtained, being equal to

66 oz. 13 dwt. 8 gr. of silver per ton.

2 " 5 " 8 " gold "

In addition to the lists of localities in which the presence of gold has been verified by my personal examination, and by assay of specimens in the laboratory of the Geological survey, I now give, in addition, several other localities, in which the existence of the precious metal has been observed by persons worthy of confidence, more particularly by Mr. Michel and Prof. Jas. T. Bell:—

1. Madoc, Range IV., Lot 15.	10. Madoc, Range VI., Lot 29.	18. Elzevir, Range II., Lot 15.
2. " " V., " 9.	11. " " VI., " 30.	19. " " III., " 9.
3. " " V., " 24.	12. " " VII., " 18.	20. Hungerford, " X., " 19.
4. " " V., " 27.	13. Marmora, " VIII., " 10.	21. " " X., " 20.
5. " " V., " 28.	14. " " IX., " 9.	22. " " XI., " 19.
6. " " V., " 59.	15. " " X., " 8.	23. " " XII., " 23.
7. " " V., " 30.	16. Elzevir, E. " I., " 10.	24. " " XII., " 24.
8. " " VI., " 16.	17. " " II., " 5.	25. " " XIV., " 8.
9. " " VI., " 17.		

Dr. Hunt's
assays.

- | | | | | |
|--|----------|----------|-----|---|
| 1. | Madoc, | range V. | lot | 2.—Dolomite adjoining the veins at the Empire mine, as free as possible from sulphurets. Trace of gold, not more than 1 dwt. per ton. |
| 2. | " | " V., | " | 2.—The ore from the Empire Mine was an antimonial gray copper (fahlerz), associated with some crystals of mispickel, iron pyrites, and a little galena. The washed and dressed ore gave to analysis, besides copper, antimony and sulphur, small amounts of arsenic, iron, zinc, lead and silver with a portion of gold. 53 ounces from the vein, gave by crushing and washing 6½ ounces, equal to 13 per cent. of ore, still containing about one-fourth its weight of sparry matter. The assay yielded a button of silver rich in gold, amounting, for the ton of 2,000 pounds of dressed ore, to—
8.72 ounces of gold.....\$206.50
120.74 " " silver..... 155.70
<hr/> \$362.20 |
| <p>Making allowance for the proportion of gangue, equal to one-fourth, still remaining in the dressed ore, we have for the pure ore a value of \$482.93. A trial of selected fragments from the same mine, in which the amount of sparry matter was not determined, gave as follows for 2,000 pounds:—
4½ ounces of gold.....\$ 96.46
57 1-6 " " silver..... 73.74
<hr/>\$170.20</p> | | | | |
| 3. | " | " V., | " | 17.—Sparling's mine, Eldorado, dolomite; said to have yielded \$53 gold per ton. No trace of gold. |
| 4. | " | " V., | " | 18.—Richardson mine, from shaft. No trace of gold. |
| 5. | " | " V., | " | 18.—Richardson mine, gray silicious dolomite, with some disseminated pyrites. A trace of gold. |
| 6. | " | " V., | " | 18.—Richardson mine, ferruginous earth from cavities in the rock, yielded by amalgamation, from a trace of gold, up to \$380 per ton. (See page 166.) |
| 7. | " | " VII., | " | 17.—Madoc Mining Co., a fine-grained, bluish dolomite, said to have yielded 13 oz. 10 dwt. of gold per ton. It gave, on assay, only a trace of gold. |
| 8. | " | " XI., | " | 16.—Shaft; quartz from a vein, with iron ochre. Trace of gold. |
| 9. | " | " XI., | " | 16.—Same shaft; quartz, with ochre. No trace of gold. |
| 10. | Marmora, | " I., | " | 30.—Shaft; quartz, with black tourmaline. No trace of gold. |
| 11. | " | " III., | " | 15.—Shaft; micaceous dolomite with thin quartz seams. Trace of gold. |
| 12. | " | " V., | " | 17.—Shaft; John's mine; vitreous quartz, with some pyrites and native copper. No trace of gold. |
| 13. | " | " VI., | " | 18.—Shaft; quartz with bluish tourmaline, calcite, and some ochreous matter, in greenstone. No trace of gold. |

REPORT OF MR. HENRY G. VENNOR.

14. Marmora, range IX., lot 7.—Shaft at Berry's mill, sixty feet deep, 6 feet wide; gangue, quartz with mispickel and free gold. Yielded me, by fire assay, 3 gr. per ton. A specimen, in which the gold was visible, yielded as high as 9 dwt. to the ounce.
15. Belmont, " II., " 18.—Specimen from shore of Belmont Lake, weathering mica slate, with ferruginous seams. No trace of gold.
16. Lake, " III., " 12.—Shaft; vein of quartz. A trace of gold.
17. " " III., " 12.—East vein; concentrated sulphurets, ran a little over \$7 per ton.
18. " " III., " 13.—Dolomite, and Deer River. A trace of gold.
19. Elzevir, " IV., lots 2, 3.—Antimonial gray copper ore, in a calcareous matrix. A trace of gold.

In the assays 16, 18, 19, the amount of gold in no case exceeded 10 dwts. to the ton.

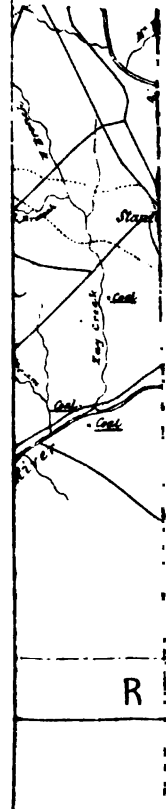
Bismuth.—The occurrence of carbonate of bismuth in the Adirondack region has been alluded to by Dr. Hunt in his Report on the Geology of Hastings, in 1867, (page 6). It was found on lot thirty-fourth range of Tudor, in a vein cutting the hornblende rocks of the Adirondack and an overlying magnesian limestone, the dip of which was a few degrees to the north of west. The vein, which is very irregular in size, sometimes attains a breadth of two feet or more, and runs N. dipping at a high angle to the south-westward. The veinstone is a vitreous quartz, carrying near the surface small masses of carbonate of bismuth, which, lower down, were replaced by the sulphuret, and finally by metallic bismuth. Fine crystalline specimens of the carbonate of bismuth, several ounces in weight, were sometimes met with. Valuable ore was sparsely and irregularly disseminated in the gangue, which also enclosed irregular layers of impure greenish masses of radiated black tourmaline, which were sometimes found to replace the bismuth ore. In sinking, the quartz veinstone was replaced by an aggregate of pink crystalline calcspar enclosing crystals of yellow mica, which were also met with in the adjacent rocks. Iron pyrites in imperfect crystals and small masses was also in the calcareous portion of the vein. Dr. Hunt, to whom I am indebted for these notices of the minerals of this curious vein, assayed the bismuth ore for gold and silver, but found neither. After considerable work the vein was abandoned in 1868.

I have the honor to be,

Sir,

Your obedient servant,

HENRY G. VENNOR



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REPORT

OF

MR. CHARLES ROBB,

ADDRESSED TO

SIR WILLIAM E. LOGAN, F.R.S., F.G.S.,

DIRECTOR OF THE GEOLOGICAL SURVEY.

MONTREAL, 22nd April, 1869.

SIR,—Having, in the month of May last, been honoured with your instructions to visit and make a geological examination of certain parts of the Province of New Brunswick, I immediately proceeded thither, and have devoted to that object the remainder of the season suitable for field work.

The region indicated by you as that to which you deemed it desirable to bestow attention in the first instance, is that lying towards the northern base of the great coal area of the Province, comprising, in addition to the Carboniferous rocks themselves, an extensive belt of metamorphic and granitic rocks, the age and conditions of which had not been previously ascertained. I also understood it to be your desire that I should investigate incidentally, in the course of the season, the facts relating to the discovery or probable occurrence of economic minerals in the region referred to.

Of that part of the Province above indicated by far the greater proportion is still in the state of an unbroken wilderness, the settlements being confined for the most part to the banks and immediate vicinity of the river St. John and its principal tributaries. In order, therefore, to obtain, in the readiest manner, a key to the geological structure, I deemed it advisable to commence with the examination of the banks of the St. John River itself, which affords a transverse section of the formations; and of the more accessible districts on either side. Accordingly, my explorations of last summer and autumn have extended over the greater part of the counties of York and Carleton, and the south-eastern part of Victoria, in which

discoveries of gold had been reported, and lands leased for gold-mining purposes. The area over which my observations have extended may be estimated at 5,000 square miles; but for various reasons, which I shall state, the work must be regarded rather as a preliminary reconnaissance than a complete and detailed survey.

Geological
map.

In the accompanying map, which I have compiled from the most authentic available sources on a scale of two miles to an inch, and on the appended sections, I have recorded many of the details of my observations; and on the smaller map, reduced from the former to a scale of eight miles to an inch, I have indicated, by appropriate colouring, the general results.* In procuring the materials for the compilation of the maps, I have gratefully to acknowledge the courtesy and kindness of the gentlemen connected with the Crown Lands Department at Fredericton.

At an early stage in the course of this investigation it became evident that, in so far at least as regards the great area underlaid by the metamorphic and granitic rocks, the attempt to conduct a systematic and minutely detailed geological survey without a previous general reconnaissance, would, for various reasons, be beset with difficulties and attended with disappointment and loss of time.

1. Owing to the altered and contorted condition of these rocks the obscurity and difficulty incident to the investigation of all such regions is experienced here in full force. The lines of original stratification are either obliterated or so complicated with the superinduced planes of cleavage, foliation and jointing as, in the absence or very rare occurrence of fossils, to render the stratigraphical relations of their component parts extremely embarrassing and difficult to trace. The remarkable uniformity in mineral character and conditions, as shown in the river sections, is also extremely perplexing when it is attempted to determine the order of succession or thickness of the various members of the formation. This difficulty is further complicated, where differences in this respect do occur, by the gradual manner in which the rocks appear to blend with each other, and by the absence of well-defined and characteristic bands capable of being traced for great distances on the strike.

2. Although the transverse sections afforded by the St. John and Southwest Miramichi Rivers (which run approximately parallel to each other at the distance of about forty miles apart) are good and easily accessible, they are too far apart to be co-ordinated for the purpose in view, and in the intervening region, which is still for the most part a trackless wilderness, the rock exposures are few and their position uncertain and difficult to find.

3. In the absence of reliable topographical maps, and of landmarks of any kind in the interior of the country, the difficulty of bringing into posi-

* The smaller map is the one published with this Report.

tion any geological observations would be extreme. I am aware that in the progress of your surveys in Canada, you have encountered and overcome similar difficulties, on a large scale; but it appeared to me a matter for consideration how far, at the outset, I should be justified, under all the circumstances, in incurring the delay and expense of investigating minute local details, the connection of which would necessarily be so vague and obscure.

In consideration of all these circumstances, it has appeared to me that a comprehensive general view of the whole conditions of the case would be a necessary preliminary even to the institution of an intelligent and economical method of subsequent procedure, and would afford at the same time an opportunity of making special examinations of those localities, sometimes at great distances apart, where valuable minerals were reported to have been discovered.

Accordingly, my observations will be found, on the whole, to be more desultory and indefinite, as materials for a systematic survey, than they would otherwise have been, or than I could wish. I have, however, on all occasions striven to make them as accurate as possible in regard to position, by reference to the Crown Lands Surveys, and to all available landmarks, natural or artificial, such as prominent bends of rivers and streams, occurrence of islands, junctions of tributaries, mile-trees, roads, etc., and by bearings to all conspicuous elevations. In determining the line of junction of the Carboniferous and metamorphic rocks, I have followed, for the most part, the usual method of pacing, where points occur in the vicinity whose position is known with any degree of accuracy. In illustration of the mineral character of the various districts, I have collected a set of rock specimens and fossils, which are also herewith submitted.

The geological features of the region in question have been investigated to some extent and described in general terms by the late Drs. Gesner and Robb, and also by Dr. Dawson, Professor Bailey and Professor Hind, to whose labours I am indebted for much valuable assistance in the prosecution of my own.

For the convenience of classification I shall, in anticipation of the results to be hereafter detailed, divide the record of my observations into six distinct sections, corresponding with the geographical and geological lines upon the small map.

General divisions.

I. The section of country lying towards the south-east part of the county of York, and overlaid by the nearly horizontal unaltered rocks of the Carboniferous series.

II. The belt or band of metamorphic rocks immediately underlying the former, up to the south-eastern boundary of the great granitic area.

III. The so-called central granitic area.

IV. The band of non-calcareous metamorphic slate and quartzite lying immediately to the north-west of the granitic area.

V. The north-western part of the county of Carleton, occupied for the most part by altered calcareous clay slate; and

VI. The Tobique valley and its tributaries, in the counties of Victoria and Northumberland.

N. B.—Throughout this Report the bearings are stated with reference to the astronomical meridian; the variation of the compass at the time of my visit was $19^{\circ} 20' W.$

I. THE CARBONIFEROUS AREA.

Lower Carboniferous.

This formation, (in which for the present I include the lower red sandstones and conglomerates usually regarded as Lower Carboniferous), in so far as hitherto examined by me, is comprised between the southern boundary of the county of York and the unconformable altered slates to the north-west. This, however, constitutes only a portion of the northern rim of the great Carboniferous area. The line of out-crop, or junction of the two distinct series of rocks, which is rudely parallel to the strike or general direction of the older rocks, is delineated upon the map from my own observations and measurements at a great many points.

The Carboniferous (or more properly, perhaps, Lower Carboniferous) rocks, in the northern part of New Brunswick, consist of a series of sedimentary deposits, evidently composed of the debris of the more ancient metamorphic rocks; and rest unconformably and almost horizontally upon the upturned edges of the latter, filling up pre-existing hollows and bays, and but slightly altered in mineral composition, except where invaded, at intervals towards the base, by rocks of igneous origin. Owing apparently to these irregularities in the surface of deposition, and to the prevalence of other disturbing influences, it is difficult to give any exact definition of the component parts of this Lower Carboniferous series, their respective volumes, or even of the order of their succession.

Lower conglomerate.

The lowest member, resting immediately upon the metamorphic slates, and apparently dipping, at and near the line of contact, in conformity with their previously denuded surface, is a coarse dark red conglomerate, composed of rounded and flat pebbles, generally, though not always, water-worn, and consisting of slate, quartz, trappean, and older conglomerate rocks of all sizes up to eight inches diameter. Such of the pebbles as are of a softer or more permeable nature are stained red and sometimes green, doubtless from the penetration of ferruginous matter. The whole mass is cemented by a calcareous and arenaceous paste, sometimes, especially towards the base, with crystalline calcite. Wherever this red calcareous conglomerate

rests immediately on the metamorphic slates, the latter seem to partake of the same characteristics, becoming more or less tinged with red and green colours, and impregnated with calcareous matter, which appears both throughout the substance of the slates, and in veins and strings of calcareous spar, frequently associated with quartz, intersecting them. The calcareous impregnation diminishes in intensity as we recede vertically or horizontally, as the case may be, from the junction of the two formations.

Succeeding the red conglomerate, which generally becomes finer towards the summit, are red sandstones, also calcareous, but more sparingly so, with occasionally interposed thin and irregular layers of red shale, sometimes so free from grit as to make a good pigment. Both sandstones and shales are sometimes highly micaceous, and the calcareous matter seems gradually to diminish in quantity from the base upwards. No fossils have been observed in these red conglomerates, sandstones and shales, the aggregate thickness of which, from observations made at several points, I have reason to believe to be about 1000 feet.

Sandstones and shales,

Then follows, but only at irregular intervals, a coarse, silicious conglomerate, composed entirely of rounded white quartz pebbles with a cement consisting of fine grains of sand and feldspar, and totally devoid of lime; above which, in very considerable volume, repose coarse grey grits or sandstones and conglomerates, also devoid of lime, abounding with carbonized casts of calamites, cordaites and other obscure vegetable remains, and holding occasional thin seams of coal. These last mentioned rocks constitute, in that part of the region examined, the most prominent feature in the main Carboniferous area. Occasionally they are fine grained, and fit for grindstones; sometimes flaggy, in tolerably regular and thin layers, but generally very coarse grained and massive, extremely irregular in the size of the component particles, and partaking, even in the same beds, of the mixed character of sandstones and conglomerates. The paste is feldspathic, and sometimes shows the result of decomposition in the presence of small portions of kaolin among the particles.

Upper conglomerate.

Although the general colour of these rocks is grey, they are occasionally reddish, purple and yellow, and more rarely of a greenish hue, and sometimes stained black with oxide of manganese; these differences being apparently quite capricious in their modes of occurrence, depending rather upon local circumstances than upon the stratigraphical position of the beds exhibiting them. At the few spots where thin seams of coal have been discovered, they are overlaid by a correspondingly thin band of drab coloured arenaceous and micaceous shale, showing scanty and imperfect impressions of ferns and other coal plants, and rest upon a similar stratum, abounding in nodules of iron pyrites, but destitute of organic remains, so far as I could discover. I am not aware of any true stigmæria underclays or

Coal seams.

other indications of productive and workable coal seams having been found in the region under notice. Near Thompson's Mills, at the mouth of the Nashwasis, about three miles north of Fredericton, two large prostrate trees have been found imbedded in the solid sandstone, one measuring fifty feet long and two feet diameter at the base; of these I have obtained fragments, but the species has not yet been identified.

General dip.

The attitude of the various strata above enumerated, which appear on the whole to be conformable, is nearly horizontal. From local irregularities; however, in the apparent surfaces of bedding, it is exceedingly rare to obtain an unequivocal observation of strike or dip by direct measurement, and from the want of continuity of the beds their precise attitude cannot be deduced from bearings and levels taken at moderately distant points. From a somewhat comprehensive series of observations, I believe I am justified in setting down the average dip, throughout the region explored by me, as E. 6° — 10° S. at an angle of 5° . This is at and near the rim of the area; as we proceed towards the centre the strata become more and more nearly horizontal.

Soils.

The grey grits and conglomerates being composed of materials little liable to disintegrate by the influences of the weather, especially towards the outer rim, have resisted denudation, and are generally found standing out in bold bluffs or more shelving ridges of various elevations up to 900 feet above tide level; while the softer and more readily decomposed red and calcareous rocks at their base occupy lower ground, and partially influence the course of some of the rivers; their ruins producing, as might be expected, good arable land. The grey sandstones, on the other hand, produce by their disintegration rather poor and meagre soils; and the uplands overlying these rocks being either for the most part encumbered with loose blocks, or swampy from want of natural drainage, the progress of agriculture in such circumstances is necessarily slow.

The trappean rocks to which I have referred as associated with this group, occur only in connection with its lower members. The areas of these eruptive rocks, of which I have noted seven distinct localities in the region explored by me, are generally of very limited extent, but locally they appear to have exercised a considerable influence upon the character and distribution of the rocks penetrated and overlaid by them.

Carboniferous area.

Having thus indicated the general features and conditions of the Carboniferous rocks in this region, I shall proceed to give a few details of the more notable localities in which they were observed. It has been long known that the great Carboniferous area of New Brunswick has a triangular form, the base resting on the Gulf of St. Lawrence, and the apex situated a little

to the west of Oromocto Lake, near the boundary line between the counties of York and Charlotte. It is at this latter point that my observations commence, extending thence in a north-easterly direction to the county of Northumberland, at Boiestown on the Southwest Miramichi River. The river Magaguadavic skirts this line transversely just at the apex of the Carboniferous triangle, and seems to have excavated its channel in the soft calcareous and marly rocks at the base of the formation; the country beyond, to the west and north, forming a very extensive elevated plain, underlaid by the metamorphic rocks. The succeeding members crop out in bold bluffs, nearly 250 feet above and two-thirds of a mile from the river; the apparent dip being N. 70° E. <15°. The section may be tabulated thus, in ascending order:—

	<i>Feet.</i>	
1. Red conglomerate and marl with impure hematite, to base of cliffs.....	60	<i>Magaguadavic section</i>
2. Red calcareous sandstone moderately fine-grained.....	45	
3. Purple sandstone, cut vertically and transversely in one place by a two-foot dyke of trap running east and west, which has to a small extent hardened and altered the rock in its immediate vicinity.....	30	
4. Reddish-grey coarse sandstone becoming conglomerate in irregular patches in the beds. The pebbles are of all sizes up to two inches diameter, chiefly of quartz and quartzite.....	30	
5. Yellowish coarse-grained sandstone with large quartz pebbles and obscure vegetable impressions.....	50	
6. Grey and purple coarse sandstone, occasionally stained black with oxide of manganese, to top of cliff.....	35	
Total.....	250	

Oromocto Lake, which is situated two miles eastward from the brow of the cliff, and is about sixteen square miles in superficial extent, is from 80 to 100 feet below the level of the escarpment referred to, and 370 feet above the level of tide water, while the general level of the great plain to the west is 250 feet; thus presenting the extraordinary phenomenon of a very considerable body of water supported at a height of 120 feet above the plain in the immediate vicinity, and yet draining through a very great area in the opposite direction. At Lister's Mills, ten miles north from the escarpment, and on the north-east branch of the Magaguadavic, the rocks at the base of the Carboniferous series present an interesting development of their peculiar characters where affected by trappean intrusions. Mottled red and green highly calcareous shales and conglomerates, some of the layers holding nodules of pure calcspar, layers of chert and strings of fluor-spar, occur mixed with rocks apparently of eruptive origin, and with others bearing much resemblance to the older metamorphic rocks.

The eruptive rocks which, to a limited extent, appear here, are situated at the south-western extremity of a lenticular shaped area about nine miles

in length by a little over one mile broad in the middle, occupied by rocks of a similar nature, attaining their greatest development at Bald Mountain and other bold bluffs at and near the foot of Cranberry (or Bear) Lake. This mass is flanked to the south by a considerable breadth of the red calcareous conglomerate and marl formerly described, forming the fertile tract of Harvey Settlement; and on the north by an extensive flat but elevated table-land, underlaid by the metamorphic slates; the water-shed between the streams flowing into the St. John River and Passamaquoddy Bay respectively. The eruptive mass appears to consist of a central and underlying part or nucleus of very hard and heavy dark red or purple compact quartziferous porphyry, holding a little calcareous spar, fluor-spar and traces of copper ore in cracks and crevices, overlaid and enveloped first by hard close-grained and homogenous yellowish-brown claystone, resembling overburnt pottery-ware, and then by a rock apparently identical in composition and equally close-grained, but finely laminated in purple and pink streaks, as if deposited from solution in water; the former being the more quartzose, and the latter the more feldspathic portion. The laminae run in the general direction of the length of the mass, and dip in opposite directions on either side of it, generally at an angle of 45° , but with many and violent contortions.* The conglomerate and marl of the lower member of the Carboniferous series appear to a very limited extent to the north of these rocks, but are chiefly developed in the opposite direction.

A good section of all these rocks is afforded by the railway cutting at the foot of Cranberry Lake; but as it intersects them longitudinally, or at a very oblique angle, it does not throw much light upon the structure, in so far as measurement is concerned. The following may be taken as an approximate estimate of the thickness of the various members of what are considered as belonging to the trappean mass, that of the sedimentary strata being here obscure:—

Thickness.

	<i>Feet.</i> *
1. Central mass of quartzose porphyry, (breadth).....	1800
2. Claystone, compact and close-grained, (thickness)	1250
3. Laminated and contorted quartzose and feldspathic rock, (thickness).	600

Within the limits of the trappean area described are four hills composed of these rocks; the highest of these, called Bald Mountain, is about 380 feet above the plain, with a steep mural face to the west, near the base of which at one point I observed the claystone trap overlying a coarse conglomerate, either of an eruptive or highly altered character. The other elevations are

* The central rock appears to bear a strong resemblance to an eruptive rock described and analyzed by Dr. Hunt under the name of *orthophyre* as occurring in the township of Grenville, Quebec. (See *Geology of Canada*, page 654).

about 220 feet in height, all very near each other, clustered around the foot of Cranberry Lake, and about the centre of the eruptive area.

A little coal is reported to have been found in the grey sandstone overlying the red conglomerate in Harvey Settlement, and hopes have been entertained in the locality that this might lead to workable deposits; but in so far as regards the character and condition of the rocks here, there is little to justify such an expectation, since they are situated quite near to the base of the Lower Carboniferous, and appear to be devoid of the characteristic underclays which accompany workable coal seams.

About half-way between the St. Andrew's and Fredericton road, and the sharp bend of the St. John River at the mouth of Long's Creek, the junction of the metamorphic and Carboniferous rocks is well exposed near the house of Nicholas Barker; where the former are seen dipping N. W. $< 80^\circ$, and the latter, now free from the influence of intrusive rocks, about S. E. $< 20^\circ$, both being highly calcareous towards the junction. The pebbles of the red conglomerate here, especially towards the base, are for the most part angular, composed of slaty and trappean rocks, and of all sizes up to six inches. The breadth of the conglomerate band and its associated red rocks is here over half a mile, and the thickness, assuming the dip to be uniform, about 1000 feet. Coal.

About five miles to the eastward of this point, where a section of the rocks is afforded at Kelley's Creek, the red rocks do not exceed one hundred paces in breadth; beyond which they no longer appear to come to the surface, nor have they been observed by me in the whole distance thence to the main river, upwards of nine miles. The silicious conglomerate and coarse grey sandstone are observed in this interval in immediate contact, dipping in opposite directions at high angles, and both devoid of calcareous matter. The Fredericton and St. Andrew's road runs for this entire distance parallel to and a little south-east from the line of junction of these formations, occupying an elevated though irregular ridge of the grey grits, at an average height of 400 feet above the main river, the tributary streams running in opposite directions on either side of this ridge. On approaching the River St. John the country underlain by the metamorphic rocks becomes more rugged and mountainous; and at and near Springhill, five miles from Fredericton on the Woodstock road, cliffs of these rocks rise to the height of from 800 to 500 feet, generally with steep mural faces to the north and east. The junction of the metamorphic and Carboniferous rocks on the right bank of the river, although concealed by the superficial deposits, I have good reason to believe to be about four and a half miles above Fredericton, near to which point the attitude of the Carboniferous rocks, where exposed, is ambiguous and perplexing; in one instance I observed the grey grits dipping apparently at an angle of 65° to the S.E. Springhill.

In tracing the line of junction to the north-east we find evidence that on reaching the main river it coincides with its course, and runs under its bed for a distance of four and a-half miles; that is, from the point above noted, to a little below the ferry at King's Clear, where it again comes out on the right bank; and enclosing a circular area of about two and a-half square miles, crosses the river at Indian village to Keswick Bluffs, and thence skirts the right bank of the Keswick River for about five miles from its mouth. The line I have described forms, as will be seen by the map, a deep sinus or bay in the older rocks, which is occupied by elevated ridges of highly contorted and altered slate and quartzite. Near Springhill, at the mouth of Sutherland's Creek, and at a few other points along this line where exposures occur, these rocks are observed to become red and calcareous, probably from proximity to the red conglomerate and marl, which, however, do not actually appear in place on this side of the river until reaching the area at King's Clear, formerly regarded as an outlier of the formation. Here the strata lying at the extreme base of the Carboniferous series, are well exposed; consisting chiefly of alternating thin beds of red conglomerate and marl, the latter occasionally holding nodules of limestone; and the conglomerate, when in contact with the slate, being composed chiefly of angular fragments of that rock, which, in ascending, are gradually replaced by rounded and transported pebbles.

King's Clear.

On the opposite side of the river, which is here expanded to an average breadth of about one and a-half miles, and studded with large alluvial islands, the red conglomerates and sandstones are displayed in considerable force from Clarke's Mountain, opposite Springhill, to Keswick Ridge on the right side of the river of that name. Clarke's Mountain is a dome-shaped trappean mass or knob rising in a bold and picturesque manner from the brink of the river to the height of 280 feet. The rock is a mass of very hard and heavy close-grained blackish-green basalt or dolerite, with perpendicular joints running east and west, about eighteen inches apart, and another set dipping S. E. $<25^{\circ}$. At the river-bank it is seen reposing on nearly horizontal coarse red sandstone and conglomerate to the height of thirty-five or forty feet, and traceable about two miles up the river, where it attains a height of 350 feet; giving a total thickness of about 1000 feet to the red rocks at this point, where the eruptive rock which caps them, with a steep face to the river for the whole distance from Clarke's Mountain, appears to terminate in a wedge-shaped point, giving place to the grey sandstone and conglomerate.

Clarke's Mountain.

The mineral character of the eruptive rock, in its continuation westward from Clarke's Mountain, is somewhat different from that found at the latter place, as above described, being of a lighter colour and inferior density, with less regularity in the arrangement of joints; vesicular and amygdala-

loidal, the amygdules being composed of calcspar, green earth, and occasional zeolitic minerals. From the termination of the wedge-shaped eruptive mass northward, the grey grits and conglomerates form the continuation of these high lands; rising to an elevation of from 400 to 500 feet, and skirting the left side of the valley of the Keswick in an amphitheatre of bold bluffs, for several miles upwards from the main river.

Three miles due east from this intrusive mass another of similar dimensions and mineral character occurs. This eminence, which flanks the Royal Road, on the south side of Nashwasis valley, and is called McLeod's Mountain, attains a height of 540 feet, and is capped by the eruptive rock to a thickness, at the only point where I could obtain an observation, of 170 feet, with a perpendicular face to the west. The rock is vesicular and uncrystalline, resembling not so much the basalt of Clarke's Mountain as its supposed continuation to the north-west. Here, too, as at the latter locality, it rests immediately upon soft red and green bedded marls with a dip to the S. E. $< 7^\circ$, overlying red conglomerate and shaly sandstone, and including angular fragments of the latter. Near Easty's Bridge, where the Royal Road crosses the Nashwasis, the eruptive mass seems to terminate in a very narrow band, at the river, where it is at least 800 feet below its lower surface in the mountain itself.

From the escarpment of the mountain the ground slopes to the south-east at a low angle, probably in conformity with the dip of the underlying grey grits, which flank the narrow coping of trap. Near the bridge the river divides into three branches, and on the north-east branch, about one and a quarter miles from the Forks, occur the Falls of Nashwasis. Here the brook, running in a picturesque gorge formed of nearly perpendicular cliffs of yellowish-grey sandstone, 100 feet apart, and about the same height, falls over coarse silicious conglomerate rocks, forming a cascade of forty feet high and fifty feet in width. Both the cliffs above, and the conglomerate forming the bed of the stream at the fall are copiously charged with carbonized impressions of obscure vegetable fossils, such as leaves and stems, the latter sometimes of considerable thickness, the bark being converted into coal, and the core replaced by sandstone; nodules of iron pyrites are also very abundant. Although such traces of carbonaceous matter abound, there seems to be nothing to justify the expectation, which has been entertained by some of the neighboring residents, that a workable seam of coal may be found here. Rumours were current also, when I visited the locality, of veins of manganese and even of more valuable ores having been found on McLeod's Mountain, together with great deposits of fine red ochre in the vicinity, but as they were not met with by me, I am unable to give any details. Just below the fall there is a considerable development of a pure white silicious conglomerate, composed entirely of large quartz pebbles, and without a trace of organic remains.

River Tay.

From the mouth of the Keswick, north-eastward as far as Tay settlement, a distance of fifteen miles, the hardness of the out-cropping edges of the grey grits and conglomerates, combined with the unequal effects of superficial denudations, produces a very marked topographical feature, forming a succession of nearly parallel ridges running north-east and south-west as far as the valley of the Nashwank, and all of very considerable elevation up to 900 feet above tide-water. Most of the rock exposures observed by me in this district have been recorded on the large map, and need not be here repeated. In this interval the red rocks are nowhere conspicuously displayed, owing to the relief of the surface, the nearly horizontal attitude of the strata, and the soft nature of these rocks themselves. In the valley of the River Tay, however, they re-appear in considerable breadth, as might be expected from the fact of its cutting the formation transversely. At Boone's Mills, about eighteen miles from Fredericton, on the north branch of the Tay, and near the road between Cardigan and Tay settlements, fossiliferous and highly ferruginous grey grits occur in alternating massive and shaly beds, dipping S. E. $< 7^\circ$, with specular iron and impressions of large and small obscure fossil vegetable remains. A little farther north, at the bridge over the south branch, thin bedded micaceous red sandstones appear, dipping S.E. apparently $< 17^\circ$; this is at the junction of the red and grey rocks. Proceeding one and a-half miles northward on the road, we find at the bridge over the North Tay, the contorted and nearly perpendicular slate and quartzite of the unconformable metamorphic rocks, seamed with quartz veins, and slightly calcareous, but only so in streaks and blotches. On descending the stream (but ascending in stratigraphical order) the slates become gradually more calcareous, arenaceous and micaceous, and assume a red colour, till at a little over half a mile below the bridge, they are covered by the unaltered beds of red marl and conglomerate, dipping S.E. $< 7^\circ$.

Tay section.

As the section afforded in the bed and banks of the Tay is tolerably complete and distinct, cutting nearly transversely to the direction of the Carboniferous rocks, extending for a distance of about ten miles from their base, and including two small seams of coal, I present the following tabulated details of it, in ascending order, commencing at the point indicated in the preceding paragraph:—

	<i>Feet.</i>
1. Coarse red calcareous conglomerate and marl.....	115
2. Red and green highly micaceous marl.	45
3. Calcareous red conglomerate with finer pebbles.....	90
4. Red sandstone.....	45
5. Measures concealed, but probably still underlaid by the red conglomerate marl and sandstone which appear at the commencement of the section	700
6. Highly indurated red sandstone.....	90

7. Coarse grey grits in a cliff forty feet above river.....	70	
8. Alternating thin bands of red, grey and greenish sandstone, the grey rock highly micaceous.....	130	
9. Silicious conglomerate.....	43	
10. Grey flaggy grits, dipping apparently S.E. at an angle of 30°, but this may be due to false bedding.....	17	
11. Flaggy grey grits alternating with more massive beds.....	550	
12. Red and green calcareous crumbly shales.....	20	
13. Massive grey sandstone.....	50	
14. Flaggy grey grits overlaid by a coal seam five inches thick, but concealed under the bed of the river.....	30	Coal seam.
15. Green hard shaly rock containing impressions of calamites and ferns overlying the coal.....	10	
16. Grey grits thin and thick bedded, irregularly interstratified, and with obscure vegetable fossils.....	2900	
N.B.—This thickness is given on the presumption that in the four and a half miles intervening between the coal at C. Urquhart's on Tay Creek, and that at Alexander McLean's on the Nashwauk, there is no break, undulation nor change of dip, of the existence of which there is no evidence.		
17. Coal seam of four inches overlaid by green shale, with vegetable impression and grey sandstone to unknown thickness.....	—	Coal seam.
Total.....	4005	

At both of the above mentioned localities where coal has been found, the seams themselves are concealed, the former by a considerable depth of water in the creek, and the latter by a crumbling bank. Thus neither the quality nor conditions of occurrence of these coal seams have been accurately established; but there appears no reason to believe them to be of any economic importance, as no true underclays have been found in this section of country, and even the continuity of the coal beyond the spots where it has been found has not been ascertained. The following is a list of the plant impressions found by me in the shales forming the roof of the beds; they seemed to be for the most part common to both localities. I am indebted to Dr. Dawson, of McGill College, for their identification:

Calamites cistii, *Neuropteris flexuosa*, *N. Loshii*, *N. tenuifolia*, (or an allied species,) *N. gigantea*, *Pecopteris arborescens*, *Annularia sphenophylloides*, *Alethopteris grandis*. At a few other localities in the valley of the Nashwauk traces of coal have been found, but apparently even less important than those included in the section.

Between Tay settlement and Stanley, on the Nashwauk, on the land of Robert Thorburn, an interesting exposure of the junction of the red calcareous conglomerate and underlying metamorphic slate rock, in vertical section, is afforded in a small ravine or gorge. The slate rock at and for some distance below the plane of contact is also calcareous, and seamed with strings of quartz and calcspar; in the same neighbourhood this rock was many years ago unsuccessfully burnt in a kiln for lime.

A similar conjunction to the last is well observed, though in horizontal

Nashwauk.

exposures, in descending the River Nashwauk, where, about a mile below Stanley Bridge, the slates, reddened and rendered highly calcareous towards the contact, are overlapped by the red conglomerate, sandstone and marl, which continue uninterruptedly in descending, for a distance of one and three-quarter miles, equivalent to a thickness of about 1000 feet; and terminate near the mouth of Cross Creek, there giving place to light-grey sandstone and conglomerate in massive beds. At Red Rock settlement and also at the mouth of Cross Creek, eruptive masses of trap protrude through the red conglomerate near the summit. At Nashwauk Bridge, on the Miramichi road, thin-bedded flaggy grey grits are seen on the bed and bank of the river, dipping S. E. $< 5^{\circ}$; and the same rocks are occasionally displayed at intervals along the Portage road to Boiestown. About ten miles from Boiestown the road skirts a considerable extent of red conglomerate, terminated towards the east by an eruptive mass of basalt similar to that at Clarke's Mountain, but more vesicular. It forms the height of land on the Portage, and is about three-quarters of a mile wide, terminating at Clear-water Brook, a tributary of the Taxis River; the other dimensions and precise form of the mass have not been fully ascertained.

South-west
Miramichi.

From Boiestown eastward for three or four miles, the right bank of the Southwest Miramichi River is flanked by an amphitheatre of the coarse grey sandstones rising to the height of 200 feet above the river, and dipping S. E. $< 5^{\circ}$; the line of this escarpment is considerably to the south of that of the bluffs at Keswick, Cardigan, etc. Near the mouth of the Taxis River, which flows into the Miramichi a little above Boiestown, a small seam of coal about three inches in thickness was reported. Four miles up the Miramichi from the mouth of the Taxis, the horizontal grey fossiliferous sandstones overlie red conglomerates and marls, dipping $< 67^{\circ}$ to the south-east. This high dip, of which some of the beds of the grey grits also seem to partake, may be due to a fault; in corroboration of which hypothesis the underlying metamorphic slate is unusually full of veins of quartz and calc-spar, as if much fractured; but on the other hand it is to be noted that with the observed horizontal breadth of the red rocks (400 yards) the thickness would closely approximate to that usually obtained for the red rocks, (1000 feet). The grey sandstones near this locality yield very fair though rather fine-grained grindstones; and some of the red marls might be found suitable for a pigment.

II. SLATE BAND SOUTH OF THE MAIN GRANITIC AREA.

The second district into which, for convenience of description, I have divided the region explored by me, is that lying between the northern

boundary of the Carboniferous area and the so-called central granitic band ; extending in length from Magaguadavic Lake to the Southwest Miramichi, and in breadth varying from nine and a-half miles on the St. John River to seventeen on the Miramichi ; these measurements being taken in straight lines at right angles to the strike. The rocks of this district consist of argillaceous and micaceous clay slates, with interposed bands of hard fine-grained, crystalline, quartzose, micaceous and feldspathic rocks resembling sandstone. These rocks, which doubtless consists of altered sediments, are generally of a light bluish-grey colour, but sometimes greenish and brown from the presence of iron in various states of oxydation. They are frequently traversed by small lenticular veins and strings of quartz, generally interlaminated, but often cutting the rocks in all directions. Occasionally they are more or less calcareous, and chiefly so at and near their junction with the newer rocks.

These schistose and compact rocks, which alternate in irregular bands of various but generally no great thickness, seem to be only varieties of the same or a similar mineral aggregate, but of different structure. At one point, as I shall presently explain, I have found fossils apparently belonging to these rocks ; but, as the stratigraphical relations of these fossils are still very obscure, it is extremely difficult to discover the geological age, original conditions of stratification, thickness, or the succession of the component parts of the present series. I have observed in the same band of quartzite, (by which, for want of a better name, I shall in the meantime designate the compact bands) no less than four distinct planes of cleavage, or more strictly cleavage, lamination and jointing, along each of which the rock seems almost equally liable to split. Throughout the whole extent of these rocks they exhibit a series of sharp plications and occasional violent contortions, which greatly increase the difficulty of unraveling their structure. It is, however, probable that the planes of division between the compact and schistose bands are to be regarded as marking the original lines of stratification. From numerous observations, many of which are recorded on the larger map, the prevailing dip, when not affected by local contortions, is N. W. $< 60^{\circ}$ — 80° ; this seems in accordance also with the general structure of the country viewed comprehensively, and with the direction of the fossiliferous band at the only locality where I have observed it. Where the plications of the strata are so numerous and so sharp, the dip so steep and almost uniformly in one direction (indicating overturns) the bands of different characters so numerous, so thin, and so much alike, and the exposures so few and interrupted, it would be impossible, in the present state of our knowledge, to construct an accurate section, or to give even an approximate estimate of the thickness of the formation.

Joints and
cleavages.

On the right side of the River St. John, the section of the country now

under consideration is for the most part an elevated and uncleared marshy flat, with no natural exposures of rock except on the ridge running from the Magaguadavic settlement to the antimony mines, and on the banks and in the immediate vicinity of the main river, where numerous minor ridges and valleys occur, running in the direction of the strike. Beyond what has been already stated in treating of the junction of the Carboniferous series, and the preceding general remarks upon the metamorphic rocks, there is nothing specially worthy of note on this side of the main river, with the exception of the antimony mines in Prince William parish, and the carboniferous outlier in the same parish and in that of Dumfries. Of the former I propose to give some account under the head of the economic minerals of this part of the province; and shall only remark here that the rocks of the locality are of the same general character as I have already described, except that they are unusually full of quartz veins, some of which contain also calcareous spar, and that they are talcose in their aspect.

**Carboniferous
outlier.**

The outlying patch of supposed Carboniferous rocks, situated about twenty-four miles from Fredericton, on the river road to Woodstock, and near to the antimony mines, is of a rudely elliptical form, the major axis being parallel to the river; it is of considerable extent, covering about fourteen and a-half square miles, being five and three-quarter miles long by three and a-quarter wide. It is chiefly situated on the right bank of the river, but a small portion extends to the opposite side. It seems to occupy a shallow trough or depression excavated in the older rocks, partly in the granitic and partly in the slate belt; the rocks of the outlier covering the junction of those underlyings. The newer rocks are nearly uniform in character and composition throughout, and consist of coarse grey grits and conglomerates combined in the same beds, and abounding in casts of calamites and carbonized impressions of various obscure vegetable forms. These rocks are apparently identical with those already described as occupying a very large area in the great Carboniferous field above the unfossiliferous red rocks; no traces of which are to be found in this outlier, which rises on the right bank to an average height of 420 feet above the river, shelving with a tolerably uniform slope towards its banks.

Although no distinction can be drawn between the sandstone and conglomerate here, in regard to stratigraphical order, the rocks show stratification, and apparently dip at a low angle, on the whole, from the exterior to the centre of the area. It is probable that the mass is of no great thickness; for at a point near its centre, and at no great distance from that of its highest elevation above the river, a fall on a branch of Jocelyne's Creek, which has cut thirty or forty feet from the present surface into the sandstone rocks, exposes at its base what appears to be a point of

the metamorphic slate protruding into the overlying sandstones. Where these repose immediately on the granite they are found, as in the case observed by yourself near Bathurst, to consist chiefly of the debris of the granite in the form of a highly micaceous sandstone, or "as if from the stratification and solidification of a layer of disintegrated granite." (See *Geology of Canada*, page 452.) A little coal is reported to have been dug up in making a superficial excavation in this outlier; but such a fact, when taken in conjunction with what is known of the general structure, is not sufficient to warrant the expectation of any workable deposit being found here. The extent of the outlier on the left bank of the river is extremely limited, not exceeding 200 acres.

At Keswick Bluff opposite the Indian village in King's Clear, the peculiar features of the slate formation are well exposed in a bold and steep cliff rising to the height of over 800 feet, close to the bank of the river, and extending nearly two miles in length. Here the alternations of schistose and compact structure in narrow bands, the varieties of cleavage and jointing, and the contortions and plications of the rocks may be well studied. At the base of the cliff a small patch of the calcareous red conglomerate appears, being doubtless connected with the area already described as having been met with on the opposite side of the river and at the mouth of the Keswick. Keswick bluff.

At Scotch settlement, near the junction of the granite, the quartzite becomes harder, the crystals of feldspar larger, and the whole more ferruginous than is usually observed, and some bands abound with large cubes of iron pyrites. Such characteristics appear to be frequently prevalent in the immediate vicinity of the granite; and here, as in many similar cases, I observed that next to the ferruginous bands, and still farther removed from the granite, the slates became more or less calcareous.

From Keswick Ridge and Scotch settlement northward as far as the River Nashwauk the country was not explored, and from its generally low and flat character, and being still for the most part a wilderness, appears unlikely to afford anything instructive. The rock exposures on the Nashwauk are not numerous, and present no features different from what I have already described, except that at a point about five miles above Stanley, where the slate and quartzite are much contorted, they are talcoid, ferruginous and slightly carbonaceous, penetrated in all directions by small strings of quartz, and by others of a peculiar white earthy mineral probably a kind of kaolin. Nashwauk.

In ascending Rocky Brook, a large tributary of the Nashwauk, which joins the main river nine and a half miles above Stanley, the exposures—as the name imports—become more frequent; their general character and prevailing apparent attitude, remaining unchanged. At the Stairs, about

two miles from its mouth, the brook falls in a succession of cascades of no great height in a rocky gorge overhung by lofty perpendicular cliffs. Immediately above this point a small tributary joins the main brook, flowing in a south-westerly direction, and about three-quarters of a mile up this creek, occur the only fossil forms which, so far as I know, have hitherto been found in these rocks.

Fossils.

The discovery of fossils at this locality, which is situated in the depths of a pathless forest; seldom visited except by the lumberer; was accidental. The fact of their existence was first brought to light by Mr. Edward Jack, Civil Engineer and Land Surveyor, by whom they were observed in the course of his professional avocations, but who seemed to have been under the impression that they were only drift fossils. Mr. Jack, however, in the autumn of 1867, communicated the fact in a short note to the Natural History Society of St. John. Very shortly after my arrival in the Province, hearing of the matter from Dr. Leith Adams of the 22nd Regiment, then stationed at Fredericton, who had visited the place, and suspected that the fossils might belong to the underlying rock, I visited the spot in company with him, and succeeded not only in obtaining numerous specimens of the loose and extremely friable forms which had been previously observed, but in tracing them to their parent bed in the solid rock.

The fossiliferous layer, which so far as I could discover, does not exceed two inches in thickness, standing nearly vertical, and in conformity with the general attitude of the strata, is a hard close-grained argillo-micaceous and slightly calcareous rock, evidently an indurated shale, scarcely distinguishable, on unweathered surfaces, from the ordinary slate and quartzite of the country, but in the joints and laminæ shewing the presence of much iron by a thick brown rusty coating. The entire rock, through long exposure, becomes a brown pulverulent mass, and it is to this weathering alone that we are indebted for the exhibition of the fossil forms, many of which are in a sufficiently good state of preservation for identification, and are tolerably free from distortion. Although it is only under such conditions that the forms are visible, the entire mass of the band is probably filled with them.

List of species.

The following is a list of the species which have been recognized and determined by Mr. Billings:—*Chonetes Canadensis*, *Leptocælia flabellites*, *Renssællaria ovoides*, *Strophomena perplana*, *Streptorhynchus* (undetermined species). This assemblage of fossils is characteristic of that part of the Gaspé limestones which constitute a passage between the Upper Silurian and Devonian series. (See *Geology of Canada*, pages 393 and 933).

As the discovery of these fossils is an isolated fact, unsupported by similar evidence in other parts of the region now under notice, and as the relations of the rocks enclosing them to the rest of the formation have not yet

been fully determined, it would be premature to assign to the whole the same geological age as that established for the fossiliferous stratum above described. It seems highly probable, however, that this discovery may lead to some modification of the views hitherto entertained by geologists with regard to the age of this schistose belt, which occupies a very large area in the Province.

On the same brook, 150 yards above the fossiliferous band, although probably closely adjoining it in stratigraphical order, an exposure of highly carbonaceous black slates appears in the bed and banks ; but as this exposure was very limited I could not discover their precise relation to the other strata adjacent. The black slates are soft and fissile, with glossy surfaces, staining the hands when touched, shewing various planes of cleavage, and traversed in all directions by thin strings of a peculiar white earthy mineral resembling a sort of clay or kaolin, apparently the same as that mentioned on a previous occasion as occurring about five miles above Stanley on the Nashwank River.

On the Southwest Miramichi the line which I have marked as the boundary between the granite and the slate, is only applicable in so far as regards the area underlaid by the main band of the former rock. Several smaller patches of granite and gneiss were observed within the breadth assigned to the latter ; but as these were only seen in the bed and precipitous banks of the river, I am not prepared to state to what extent they pervade the rugged and mountainous country on either side.

I have already, in treating of the Carboniferous rocks of the Miramichi, indicated the point, at (Campbell settlement,) at which they overlap the slate and quartzite, and have referred to the manner in which the latter rocks are apparently affected at the contact of the former. In ascending the river, the slate and quartzite occupy an uninterrupted breadth of six and a-half miles, nearly across the strike, presenting no features different from those already noted in the general description of these rocks, except that the prevailing dip seems to be S. E. at a high angle. Above this point the course of the river becomes exceedingly tortuous, running for the most part in a deep gorge, and the changes of rock are frequent, although, in most instances, not sharply defined ; thus rendering any attempt at exact measurement difficult and unsatisfactory. I shall therefore, on the present occasion, merely indicate in a concise manner the nature, localities and approximate thicknesses of the various descriptions of rock met with. The point of departure from which the distances are estimated is the junction of the two great divisions of the rock formations at Campbell settlement ; the distances themselves, and the thicknesses of the various bands being measured in a straight line across the strike of the rocks.

At the point above indicated, near Lower Birch Island, (six and a-half

miles from Campbell,) there occurs what I take to be a dyke, ten or twelve feet wide, composed at the surface of a soft brown-weathering, argillaceous rock with much iron and manganese, apparently cutting the rocks, and with a course a little E. of N., succeeded by a band of red and green slate about 1000 feet in aggregate thickness, also much stained with oxide of manganese, and apparently dipping S. E. $<75^{\circ}$. At the mouth of Trout Brook, (seven miles) a very hard green, highly feldspathic quartzite, which appears to have the same dip as that above noted. At seven and a-half miles, a band of very hard close-grained cherty rock resembling Lydian stone, four feet wide, holding much iron pyrites and imbedded in light green micaceous and ferruginous slate. At Falls Brook, (seven and three-quarter miles,) there is a band of highly ferruginous soft, black, but rusty-brown weathering slate, the attitude of which is vertical, and the breadth about 50 yards. The fall is about a quarter of a mile from the main river, the brook running on the strike of the rocks, which, apparently by the influences of the weather and the eroding action of the stream, have been excavated into a triangular gorge about 300 yards wide at the main river, with almost perpendicular sides 300 feet high, converging to a point at the fall, which has at least 130 feet of uninterrupted descent, presenting singularly wild and picturesque scene.

The next tributary, falling in, as nearly all do, on the left bank, is Rocky Brook, nine miles from Campbell, between which and Falls Brook occur black and greenish banded or ribboned very hard slate and quartzite, dip S. E. $<60^{\circ}$; then alternating bands of hard purple quartzite and yellowish feldspathic sandstone, resembling a fine-grained imperfectly formed granite. These bands, of which there are at least two of each description of rock, are from 50 to 100 yards in width respectively, and dip S. E. $<75^{\circ}$. The quartzite bands are much seamed with quartz veins running north and south, corresponding with the direction of the more conspicuous joints of the granite throughout; and immediately above these alternating bands appears a considerable mass of granite, extending from one-third of a mile below Rocky Brook upward for one and three-quarter miles, succeeded by a breadth of about 400 yards of banded black and green quartzite, resembling that previously noticed.

Then follows an equal amount of ordinary quartzite, still with S. E. dip, underlaid by a breadth of 100 yards of highly ferruginous decomposing quartz rock, in some places resembling an altered conglomerate, forming a very high steep crumbling bank; giving place, about eleven miles from Campbell, to true granite, extending uninterruptedly to Snake Brook, distance of three and a-half miles, with the exception of one interposed band, not over 300 yards wide, of highly ferruginous quartzite. Between Snake Brook and Burnt Hill Brook, a distance of one and three-quarter

miles, the banks are occupied by quartzite dipping N. W. $<80^{\circ}$, and gradually, on approaching Burnt Hill, appearing to pass into a variety of gneiss, dip N. W. $<60^{\circ}$. The rocks near the mouth of Burnt Hill Brook are cut by numerous transverse veins of quartz, holding much iron pyrites and occasionally a little molybdenite. The direction of the veins, as in the case formerly cited, coincides with that of the more prominent joints of the granite, a large apparently isolated mass of which occurs about half a mile up Burnt Hill Brook. Immediately at the mouth of the brook, however, a band of very hard close-grained variegated or ribbanded silicious slate is interposed, and probably lies directly in contact with the granite, which scarcely makes its appearance on the main river, and seems to thin out to a point a little above the mouth of the brook. The aspect and attitude of the rocks here would seem to indicate that the granite lies in a synclinal, for immediately above the point last referred to, the gneiss re-appears, with S. E. dip $<60^{\circ}$, and sometimes enclosing in its beds masses of granite, as if detached from the main body and incorporated with the gneiss, which gives place again, in ascending, to fine-grained hard compact quartzite.

This description of rock continues, and with the same attitude, to Little Burnt Hill, one mile higher, where the dip seems again to change to N. W., and green micaceous schists, with quartz veins holding pyrites, are intercalated. The quartzite continues in bands of varying hardness and colour, and passes near the mouth of McLean Brook, sixteen miles from Campbell, into a very hard black slate rock, standing vertically, and continuing, with no perceptible change except that it becomes of a deep bluish tint, as far as Slate Island, where patches containing considerable calcareous matter, iron pyrites, and traces of copper pyrites were observed. Above Slate Island for one mile no change was noted except the absence of lime in the slate; then a band of gneiss 400 yards in width, succeeded by feldspathic slates of about an equal amount, and again, at or near the northern boundary of the New Brunswick Land Company's tract, by heavy bedded black micaceous gneiss. A very short distance above this point, near McDonald's Brook; seventeen and three-quarter miles from Campbell measured in a straight line across the strike; is the line which I have drawn on the maps, as the division between the main granitic area and the slate and quartzite band.

III. THE CENTRAL GRANITIC AREA.

The distinction noted in the close of the last section, and implied by the title given to the present, may appear to have been drawn somewhat arbitrarily; for the so-called slate and quartzite band includes, as we have

seen, three very considerable, besides some smaller, bands of granite ; although the prevailing rock of the section is undoubtedly of the nature designated by the terms used. The region beyond, and on the north-west side of the line referred to, appears to be occupied, for the most part, if not entirely, by granitic rocks.

In attempting to define or map the rocks of this region much perplexity is occasioned by the gradual manner in which many of the various feldspathic rocks seem to merge into each other. Not only does this remark apply to the granite and gneiss, which are sometimes blended in such a manner as to defy all attempts at exact definition ; but even the foliated semi-crystalline slate and quartzite frequently appear to partake of the same characteristics. In exploring the rocks of this region no evidence was met with of the injection or upheaval of the granite among the stratified rocks, or of the derivation of the latter from the former. I suspect, however, that, on the whole, the granite will be found generally to occupy a lower position stratigraphically than the other rocks.

Granites.

The granite presents great varieties in colour, texture, and in the proportion of its component minerals. In general the mica is rather sparingly diffused, and sometimes altogether wanting, and the feldspar crystals frequently attain a great size, up to an inch and a-half in thickness. Occasionally irregular fragments of gneiss of all shapes and sizes are found imbedded or rather incorporated in the granite, and *vice versa* ; but no appearances of granite veins cutting the laminated rocks are noted. The direction of the granite band, whether taken as a whole or locally when seen in contact with other rocks, coincides with the general strike of the country. It is, however, extremely rare to find such junctions exposed, as the granite, probably from being more readily disintegrated, has suffered more from superficial denudation and atmospheric influences, and consequently underlies low flat land, except when flanked and protected by more resisting rocks. Within the limits assigned to the main granitic band other rocks sometimes occur, as will presently be seen.

The breadth of this band on the South-west Miramichi, in a direct line, is ten and a-half miles, extending from the point already noted to about half a mile above the forks of the north and north-west branches. Throughout the whole of this distance the country is an extensive, level, heavily wooded flat, affording no rock exposures, except occasionally at great intervals in the bed and banks of the river. Although other rocks may, and probably do, underlie this district, they are entirely concealed, and the exposures are uniformly of granite, although not always of the same character. At one place, a little below Lewey's Falls, nineteen miles from Campbell, a fine-grained yellowish feldspathic sandstone, resembling that described as occurring near Rocky Brook, is seen for a

Sandstone,

considerable breadth, succeeded by a thin band in which a multitude of angular fragments of gneiss appear to be enclosed in granite, then by gneiss, and last of all, at the falls, by true granite in massive beds, extending probably to the forks, twenty-six and a-half miles above Campbell in a direct line across the strike, through forty-six miles in following the tortuous course of the river, which, throughout the whole distance, is wide, deep and rapid, and much obstructed by huge granite boulders. The average fall I should estimate to be at least eight feet in a mile.

The region lying towards the head waters of the Nashwauk and Becaguimic has not been traversed by me, and I am indebted to Mr. Edward Jack for such facts regarding it as I have recorded on the larger map, and which I believe may be relied on as authentic.

At Hayneville and Springfield, which are included within the granitic belt, and where there are several ridges and hills composed partly of this rock, a considerable extent of country is nevertheless underlaid by very hard close-grained ferruginous feldspathic quartzite, resembling petrosilex, and sometimes traversed by great veins of quartz, holding much silvery mica. There is also found in this vicinity, and near the most northerly part of Hayneville settlement, a band of carbonaceous slate resembling that near Rocky Brook on the Nashwauk, its attitude being apparently conformable to that of the adjacent feldspathic and ferruginous rocks; but its true relations, as in the case of the Rocky Brook band, have not yet been accurately ascertained.

On the river St. John the granite band extends from the upper end of Great Bear Island, twenty-four miles above Fredericton by the river banks, to a little below Sullivan's Creek, a breadth of fifteen and a-half miles measured in a straight line across the strike. Throughout this breadth the granite is of a very varied character, as before noted with respect to that on the Miramichi. Included bands of gneiss and gneissoid quartzite are irregularly distributed, the Meductic Rapids owing their origin apparently to the varying hardness of the rocks; the carbonaceous slates appear to be nowhere represented in this section, unless it be at a point a mile and a half below the Nackawicac River, where an extremely hard jaspery rock, resembling Lydian stone, abuts upon the main river. On the right side of the river the granitic region has only been explored by me along the bank, and towards the junction of the supposed Carboniferous outlier; the limits, however, as provisionally laid down on the maps, are given on good authority.

IV. NON-CALCAREOUS SLATE BAND NORTH-WEST OF THE GRANITE.

This division comprises the rocks underlying parts of the counties of York and Carleton, extending on the St. John River from Sullivan's

Creek to a point a little above Woodstock, or a breadth of sixteen miles; and on the Miramichi seven miles, measured in a straight line across the strike; from the forks of the north and north-west branches. These rocks present few characters to distinguish them from the band already described as lying on the other side of the granitic belt, and, in the absence of evidence to the contrary, may be assigned to the same geological age. It will therefore be unnecessary, on the present occasion, to enter into any detailed description, and I shall proceed to notice a few of the most prominent points of distinction which have come under my observation.

Mica-schist.

On the St. John River, immediately above Sullivan's Creek, extending about five hundred yards upwards, and apparently in contact with or close proximity to the granite, occurs a band of highly ferruginous finely laminated mica-schist, traversed longitudinally by large quartz veins, and dipping N. W. $< 30^{\circ}$ – 50° . This is succeeded by ordinary clay slate and quartzite, which continues, with many sharp convolutions and folds, but preserving the prevailing north-westerly dip at high angles, to Patchell's Ferry, four and a-half miles from Woodstock. Here the rocks begin to assume a more crystalline aspect, and all around Woodstock afford evidences of an abnormal and disturbed condition. Bands of crystalline rocks, resembling granite, syenite, diorite, (occasionally with trappean rocks) and sometimes holding epidote, iron and copper pyrites, galena and other minerals, are intercalated in the manner of conformable or imbedded masses. Some of these I have represented upon the map, but they are too numerous and too varied in character, and have not been studied sufficiently in detail to admit of an exact description.

Crystalline rocks.

Woodstock.

I observed isolated patches, generally of no great extent, of an altered slate conglomerate composed of rounded and angular fragments of the surrounding rocks, cemented by a feldspathic paste into a hard rock; these are probably lenticular masses occupying depressions in the older rocks. About half-way between Upper and Lower Woodstock, on the right bank of the river, an interesting exposure of green quartzose and epidotic rock, jointed so as to present some appearance of columnar structure, occurs; near the Iron Works the same kind of rock, but devoid of the peculiar structure referred to, occupies a considerable breadth; and near Lower Woodstock a narrow band of red and green fine-grained and very regularly laminated slate, not over thirty feet in thickness, was observed running conformably with the general strike, but dipping S. E. $< 40^{\circ}$. The whole district is exceedingly interesting to the geologist, and especially so in connection with the deposits of iron and copper ore in the vicinity; but would require, in order fully to elucidate its structure, a more careful and detailed examination than I had it in my power to give.

In this section, a remarkable exception to the general character and

distribution of the rocks, as above described, occurs in the form of an extensive outlier of supposed Lower Carboniferous strata, occupying an area of probably not less than sixty or seventy square miles, chiefly in the parishes of Brighton and Peel, in Carleton county. This outlier has not previously, been specially described, so far as I am aware.

Carboniferous
outlier.

On the left bank of the St. John River, opposite Campbell Island, two miles below the mouth of the Beccaguimic, a band of conglomerate, 560 yards broad, abuts upon the river. It is here of the character described as belonging to the silicious conglomerate band of the main Carboniferous area ; or rather partaking of a combination of this with the underlying red calcareous conglomerate of the same series, with which, on tracing it to some distance inland, it becomes completely assimilated. The north-western outcrop of this outlier, as delineated upon the maps, has been traced by me, at intervals, for a distance of twelve miles ; and a partial traverse has been made near the centre to a distance of one and a-half mile ; where at S. B. Orser's mill, on the north branch of the Beccaguimic, coarse red sandstone and conglomerate appear to dip N. W. $< 27^{\circ}$. For the further information which has enabled me to trace approximately on the maps the boundaries of the outlier, I am indebted to Mr. Edward Jack, who, in the course of his surveys for timber locations, traversed this region in the fall of last year, and at my request, noted any remarkable geological facts which came under his observation. His remarks in reference to this outlier, which were not communicated to me until after my return to this city, are necessarily somewhat general, although sufficiently explicit to justify me in assigning to it provisionally, the limits laid down on the map ; and I consider it unnecessary to give them in detail, as you will probably deem this interesting field worthy of further special research.

On the right bank of the St. John River, a little below the band of silicious conglomerate already referred to, a somewhat similar deposit, but entirely resembling the red calcareous conglomerate and sandstone of the Carboniferous series, is displayed to the extent of 1,200 yards in breadth. Where evidence of stratification occurs in this deposit, it appears to dip to the north-west in the same direction as the metamorphic slates by which it is enclosed on both sides, although at a lower angle. The same band is traceable for seven miles on the strike, extending to the rear of the Woodstock Iron Works, where it thins out to a point, and terminates about 100 yards south of the Jacksontown Road. This is probably connected with the conglomerate and sandstone area in Brighton, as already described, but here is either brought into position by a dislocation, or occupies a narrow and shallow wedge-shaped cavity in the older rocks. The only distinction I can observe between its condition and that of the lower red calcareous conglomerate of the main Carboniferous area ; consists in the fact that here the

rock appears to be affected by numerous small faults or slips, which, in maintaining their straight course, have cut through pebbles and matrix alike.

V. CALCAREOUS CLAY SLATES IN CARLETON AND VICTORIA COUNTIES.

Calcareous
slates.

The narrow strip or belt of red conglomerate just described, together with the north-western boundary of the outlier in Brighton, constitute, with their continuation on the strike on either hand, the limit of the non-calcareous slates; beyond which to the north-west, without any perceptible change of attitude or general conditions, commences a set of calcareous slates and quartzites, extending on the St. John River, to and far beyond the Province line. These rocks, which present a remarkable uniformity in character for very great distances, precisely resemble those which have been described by yourself as occurring and attaining a great development on Temiscouata Lake and the river Madawaska, and for a great distance down the St. John River, and are in all probability the continuation of the same series, which you have determined to be Upper Silurian. The general description of these rocks given in the *Report of Progress* for 1849-50, page 60, is so concise and graphic, and at the same time, in its main features, so precisely applicable to those now under notice that I may be excused for quoting it here.

“The next five miles across the measures are occupied on the west side of the lake by calcareo-argillaceous slates, occasionally interstratified with non-calcareous bands, and some of the beds are more arenaceous than others. The colours are dark bluish-grey, light-grey and black; the divisions of the original bedding are obliterated, and in fresh fracture it is only by the colours, the differences of which are often very obscure, that the stratification can be made out; but the action of the weather and water on the ice-rounded or *moutonnée* forms which come upon the lake, distinctly shews the bedding by the unequal wear of the more or less calcareous layers, the one standing out in beads, and the other re-entering in grooves. The beds are almost universally thin, and the surfaces give a pictorial display of a vast variety of the most complicated contortions, sometimes in folds leaning over each other to the north-west, and sometimes in involved arrangements which it is quite impossible to disentangle or understand without a larger exposure than usually appears. Combined with the contortions there are often disruptions or dislocations which, however, shew no veins of interposed foreign material; the torn and twisted mass having been apparently compressed together and become cemented in such a way that, except for the colours or unequal wear, it would never be suspected that it had been disturbed at all. In some parts, however, these contorted rocks are cut up by a multitude of small veins of calcareous spar.”

I have to add to the above description that the bands of non-calcareous quartzite in the region explored by me, although in general conformable, appear sometimes to cut the rocks transversely to their strike; they vary from eight to thirty feet in thickness, and are usually traversed by small strings of calspar. Where they abut upon the river banks the exposures are usually more extensive, than at other points, as if, from their superior hardness, they had more effectually resisted atmospheric influences and the erosive action of the river. There also occur in this region a few apparently isolated patches of limited extent, of more or less pure limestone, ~~probably~~ probably lenticular in form, sometimes of a slaty structure, and sometimes massive. In two instances which came under my observation, where the rock seemed to have undergone little alteration, I discovered a few obscure fossil forms which, however, were scarcely visible except on weathered ~~surfaces~~ surfaces; but which have been recognized by Mr. Billings as Upper Silurian.

Intercalated with the calcareous slates of this region are some remarkable bands of highly ferruginous red and green slates, sometimes traceable for great distances on the strike. The first and most important set of these bands is that in which are situated the deposits of iron ore which ~~have been mined at Jacksontown, near Woodstock; and which, in their continuation to the north-east, display at their out-crop near the Beccaguimic, twelve miles from Jacksontown, very considerable quantities of a similar ore, being an impure slaty hematite.~~ ^{Iron ores.} In the Beccaguimic district there are three parallel bands of red and green slates about half a mile apart; one of these only, that nearest the river, appears to contain workable deposits of ore. Towards the south-west the Jacksontown band is traceable to the boundary line, and far into the State of Maine; where I observed it, near the boundary line, it was charged with iron pyrites. Another band of the red and green argillites is traceable from Flanigan's Hill, in Simonds, to East Glassville, a distance of nearly eight miles, and has yielded in some places good specimens of hematite and specular iron; it is five and three-quarter miles distant across the strike from the former. It would seem reasonable to expect that these bands would serve to mark the structural arrangement; but as their attitude in every instance where they were observed is vertical, and their association with other bands obscure from want of exposures, I have been unable as yet to make them available for this purpose.

A remarkable band of diorite was observed in crossing the road passing through East Glassville, about two and a-half miles south of Miller's Corners. It appears to run in conformity with the slate rocks, and is 150 yards wide where it crosses the road; in its continuation to the north-east on the strike, it appears to run into a ridge of considerable elevation

GEOLOGICAL SURVEY OF CANADA.

at three miles distant in Garforth Mountain, which is about 1. The succession of rocks observed in the vicinity of the in traversing it from north to south is as follows: 1. Calcareous the prevailing rock of the country. 2. Black slate, and. 3. Diorite band, 150 yards wide, coarsely crystalline, of dark-green colour, with many seams and joints filled with spar, especially towards its junction with;— 4. Slaty limestone of thick. 5. Highly ferruginous decomposing calcareous another band of diorite of a laminated or gneissoid aspect than the former. 7. Calcareous slate, as at the commencement; the whole of which is comprised within a breadth not 10 yards, the attitude of all the rocks being vertical. In the region underlaid by the calcareous slates, the soil is, as might be expected, superior for agricultural purposes, to that in which the rocks chiefly prevail.

VI. TOBIQUE VALLEY AND TRIBUTARIES.

From the result of my explorations of last season, I undertook an excursion to Tobique and one of its most important branches, the Serpentine, with the view of making an examination of the great Lower St. John's outlier there, and partly to visit certain lands which had been reserved for the Government on the latter stream for gold mining purposes. The Tobique is a large tributary of the St. John, falling into the main river about fifty miles above Woodstock, from the north-east, its general direction coinciding with the strike of the rocks of the country. It has a source in the high lands constituting the water-shed between the St. Lawrence and the Gulf of St. Lawrence; one of its main branches, called the Left-hand Branch, with a general south-easterly course, has a short portage with the Nepisiguit flowing into the Bay of James; the other or Right-hand Branch, falling into the main river at the same point, but from the opposite direction, through a very mountainous country, is, in its turn, composed of two branches, the Left-hand and Serpentine rivers. These streams form a junction at a point about ten miles from the main forks, from which point the Tobique flows through a rich and fertile valley in a south-westerly direction to the St. John River, a distance of sixty-two miles, following the course of the stream. On the Serpentine, which had not previously, I am aware, been visited by any one with the special view of examining its geological features, the land leased for mining purposes is about three miles from its junction with the Campbell River, and some twenty miles higher, the stream for the greater part of

the distance cutting across the strike of the rocks; but, owing to the extreme difficulty of exploring this region, I was compelled to content myself with penetrating about seven miles from the commencement of the leased lands, or twenty miles from the main forks of the Tobique.

The main Tobique, for about two miles from its junction with the St. John, flows with great rapidity through a deep, rocky gorge, its course nearly coinciding with that of the slates, which dip N. 70° W. $<60^{\circ}$; they are here highly calcareous, and enclose many seams and bunches of pure calc-spar. Half a mile higher a narrow band of red and green slate occurs, associated with a tolerably pure compact or massive limestone, containing fossils, apparently in considerable profusion, although only visible on weathered surfaces. Among them, according to Mr. Billings, are *Favosites Gothlandica*, *Atrypa reticularis*, and *Strophomena perplana*, belonging to the Upper Silurian series. Above this the river assumes a course nearly at right angles to the strike, cutting sparingly calcareous but highly ferruginous and contorted brown-weathering slate and quartzite, which must underlie those formerly referred to as prevailing at the mouth of the river. Small straggling strings of galena were observed at one place filling cracks in the rock, but are of no economic importance, except as indicating the metalliferous character of these rocks. At three and a-half miles from the mouth, measured in a straight line on the strike, the soil assumes a red tint from the proximity of the red conglomerate of the outlier; a small patch of which is visible in the bank here, but is again succeeded by the older rocks, till reaching Red Rapids, four and a-half miles up, where this formation; apparently identical in character with that mentioned in other parts of this report as the lowest rock in the Carboniferous series; appears in force in the bed and banks of the river, dipping due E. $<4^{\circ}$, extending over half a mile further up stream, and forming a steep, rocky channel.

Silurian fossils.

Carboniferous series.

Above this point the rock exposures are few, and for a distance of nine and a-half miles indicate no change, except in the prevalence of finer red calcareo-arenaceous sediments in ascending. Then, about half a mile below the Wapakehegan, appear red, grey, and green marls, interstratified with blue limestone, all in thin alternating bands, still dipping slightly S. E., and extending to the mouth of that tributary; a little above which the limestone re-appears in more massive beds, some being thirty inches thick, interstratified, as before, with red shales or marls, also of greater volume. This is a distance, in a straight line, of fourteen and a-half miles from the mouth of the river, and here the outlier attains its greatest breadth, of about nine miles, of which by far the greatest proportion lies on the south-east side of the river. The general character of the limestone of the Tobique outlier is fine-grained, with conchoidal fracture, mottled red

Marls and lime tone.

or pink and green, but sometimes bluish-grey; frequently seamed with calcareous spar, and containing, according to Professor Hind's analysis, 82.6 per cent. of carbonate of lime.

Gypsum.

Superimposed upon the limestone and marl beds here, are heavy beds of gypsum, which first appear at the mouth of the Wapskehegan, but in much greater development at Plaster Cliff, a mile and a-quarter higher; where, for a distance of 80 or 100 yards, they rise perpendicularly from the left bank to a height of 120 feet. The great body of the rock is an impure, massive but earthy and exfoliating red and greenish gypsum, containing a varying proportion of carbonate of lime and silicious matter; but it is seamed with layers of pure white gypsum and of fibrous selenite, containing, according to the analysis of the late Dr. Robb, 77.7 per cent. of sulphate, and 3.0 per cent. of carbonate of lime. Nodules of nearly pure carbonate of lime are occasionally met with, imbedded in the red gypsum. The whole appears to dip S. E. at a very low angle, and to be of limited extent, where it abuts upon the river; but I am informed, on competent authority, that the plaster beds are traceable at least four miles up the Wapskehegan, alternating with the other rocks of the series. Two small brooks were observed flowing into the river near the junction of the gypsum and marl beds, the waters of which were decidedly saline and brackish; this character being, doubtless, derived from salt springs, which however, were not met with.

Amygdaloids.

Above Plaster Cliff, for a distance of eight miles, the strata, which are now horizontal, consist, as before, of grey and red sandstone and conglomerate, blue, red and green limestone, and marl; thereafter, at the point indicated, near Phillips's Brook, promontories and low knobs of dark brown amygdaloidal trap appear at intervals among the red rocks on the left bank, becoming more numerous and extensive in ascending the river. The red rocks, however, continue to occupy exclusively the bed and right bank of the river, and occasionally also appear on the left bank, but now with westerly dip, until a point thirty-one and a-half miles from the mouth is reached, where the outlier may be said to terminate; although for the last three miles of this distance, or from Blue Mountain upwards, only slight traces of its existence can be detected in the red colour of the rocks in the bed of the river, where they are at rare intervals seen in place. Thus the total length of the outlier, measured in a straight line, may be stated at twenty-seven miles; it is of a rudely elliptical form, and its total area is not less than 190 square miles. It is bounded on all sides by ferruginous and generally non-calcareous contorted slates and quartzite, its outlines forming a very marked topographical feature, being defined in every direction by lofty ridges of the older rocks. A comparison of the rocks of the outlier, both in respect to their mineral character and apparent

order of sequence, leaves little room to doubt that they belong to the same series which I have described as lying at the base of the main Carboniferous area of the Province.

Blue Mountain, rising with a steep slope immediately from the bank of the Tobique, fifty-one miles from its mouth, as measured along the windings of the river, attains a height of 1,641 feet above the sea, and displays the red rocks towards its base. It was not ascended by me, but from its contour and surrounding conditions, seems to be composed mainly of eruptive rocks, of which a great variety, probably detached from its sides, are strewn in boulders and pebbles in the bed of the brook which bears its name. The same description of rocks, offering many varieties of colour and texture, occupy the left bank of the Tobique for over three miles above the last mentioned brook, and have apparently altered the red sandstone and conglomerate of the outlier into a hard jaspery rock. At Riley Brook, thirty-four and a-half miles in a straight line from the St. John, light green very soft non-calcareous clay slates are displayed, but only to a limited extent, succeeded by the same hard highly feldspathic brown-weathering contorted slate and quartzite already so frequently referred to, extending to, and for an unknown distance beyond, the main forks of the Tobique, and within three miles of those of the Campbell and Serpentine rivers. This character, in fact, seems to be generally prevalent here over a very large tract of country, and does not appear to differ in any important particular from that which I have described in reference to Sections II and IV, into which I have divided the region explored by me.

Some of the highest mountains in the Province are situated in the remote region and among the rocks now under review. I ascended one of these, called Bald Mountain, which I found to be 2,060 feet above the sea, or 1,535 feet above the Tobique at its nearest point. It stands alone, in the midst of a comparatively level country, the distance being five miles from the Tobique and about the same from the Right-hand Branch. The mountain, from base to summit, is nearly conical, its sides sloping at an angle of 35° to the horizon. The rock, wherever exposed, consists of a very hard ferruginous feldspathic quartzite in massive beds, weathering to a brownish-white or cream colour, dipping N. W. $<65^{\circ}$; no change either in the nature or attitude of the rocks was observed from base to summit.

Soft ferruginous slate and quartzite, some of the bands of which are highly calcareous and contain impressions resembling fucoids, are seen a little above the main forks of the Tobique, with north-westerly dip $<60^{\circ}$; above which, in ascending the Right-hand Branch, and for a distance of four and a-half miles, measured in a straight line across the strike, heavy-bedded greenish yellowish-white and brown-weathering quartzites, sometimes very slightly calcareous and pyritiferous, occupy both banks of the

river, rising in abrupt cliffs to a uniform height of 600 or 700 feet, resembling an artificial embankment. About five miles from the main forks of the Tobique, and the same distance from those of the Campbell and Serpentine rivers, the lamination, and probably also the dip of the rocks changes to S. E. ; and a band of excessively hard and tough silicious rock, resembling petrosilex, and exhibiting a tendency to columnar structure, crosses the river, forming a fall of moderate height. This is precisely on the line of strike from Bald Mountain, about five miles to the south-west.

Metalliferous
veins.

About three miles higher up the branch a high ridge, running also in the direction of the strike, abuts against the river, with apparently a similar nucleus of hard rock, which, however, in this case, resembles some of the red trappean rocks described as occurring near Bald Mountain in York County, at the base of the Carboniferous series. This ridge deflects the course of the river sharply to the north-east, about the forks of the Campbell and Serpentine. At a point called Salmon Hole, where the red trappean rock first makes its appearance on the bank of the river, a narrow band of soft green argillaceous slates, with glossy surfaces, occurs, seamed with numerous small lenticular veins of quartz, carrying iron pyrites and a little galena, and said also to yield some silver. The breadth of the hard red rock, which, however, seems to include some narrow bands of slate, does not exceed half a mile ; it is followed, at the forks of the Serpentine and Campbell, by light green quartzite devoid of metalliferous indications, dipping N. W. This continues, with interruptions from two narrow belts of the red and dark green glossy rock, for three miles up the Serpentine, where the mining leases commence, at a point where traces of copper pyrites are said to have been seen in dark grey contorted slates seamed with quartz veins, and resembling those on the St. John River, a little below Woodstock. Two miles higher a band of yellowish-red trap, or other hard rock, again deflects the course of the river sharply to the north-east ; and a mile beyond this point, or six miles from the forks, a band of highly pyritous slate appears, followed by light grey micaceous schist, with much interlaminated quartz, or rather a mixture of quartz and slate, in which gold was said to have been found. The breadth of this band is uncertain, though probably not great ; it is succeeded by a compact quartzose and feldspathic rock resembling petrosilex, showing no traces of metallic minerals, but sometimes of a feebly laminated structure, resembling gneiss ; and which gives place, at a distance of eight and a-half miles from the forks, to a band of granite not exceeding 600 yards in width, over which considerable fall in the river occurs ; and above this the same alternations of gneiss and quartzite which were observed below the granite band, but without the talcoid and pyritiferous slates. This was the limit of my observations in this region.

ECONOMIC MINERALS.

To this branch of the subject I have alluded incidentally in describing the rocks at the various localities where minerals capable of such applications exist, or are supposed to exist. From a very early period in the history of this Province, much has been said and written regarding its mineral wealth, both in coal and the metals; and capital has been to some extent employed in the development of its mineral resources, although it is to be regretted that hitherto the success which has attended such ventures has not been very marked. ¶ My own observations have not been made with any very special reference to this subject, but, in so far as they have been directed to it, I confess that I have been somewhat disappointed, both as regards the probabilities and actual results. Mere indications of valuable ores or minerals are insufficient to constitute a mining region; and the failure of operations undertaken on inadequate grounds acts as a check upon others which may have a legitimate basis, and tends to retard rather than promote the mining interests of the Province.

With reference to the small portion of the Carboniferous area examined by me; I have already given my views as to the futility of any expectation of the occurrence of workable coal seams in these rocks, which are altogether below the productive coal measures. The sandstones are in general too coarse-grained and too ferruginous to make a good building material, although some of the beds of purple sandstone appear well adapted for such purposes. In some places I found them tolerably well suited for grindstones, flags and tiles. The red marls towards the base of the series may be available as a pigment, where free from silicious matter; and excellent brick clays, some of which seem also to possess the qualities of fuller's earth, abound.

In the metamorphic rocks of this region the first mineral of economic importance which claims attention, is antimony. The antimony mines of Prince William have been worked at intervals and to a small extent for six or seven years at three adjoining locations situated twenty-four miles from Fredericton and three miles from the Woodstock road. The rock of the country is talcoid slate and quartzite, coinciding in strike and dip with that generally prevalent throughout the section. The mines are in the immediate vicinity of the supposed Carboniferous outlier of Prince William, and within two miles east of the junction of the slate and granite. The veins, which have been partially developed by mining, have the character of true or fissure veins cutting the rocks, and thus may be expected to prove persistent in depth. Two of them have a course nearly parallel, and at the distance of about one hundred feet apart, underlying due N. $< 45^{\circ}$ — 52° ; while the third has a bearing exactly at right angles to these,

and underlies to the E. $< 43^\circ$. In the former cases the matrix is slate and quartz, without any admixture of calcareous spar, while in the latter a considerable amount of this mineral is found in the vein. The ore is stibnite or sulphuret of antimony, occurring both in pure solid masses, and more or less mixed with the gangue. The thickness of the veins, which is nearly the same at the different locations, varies in the same shaft from four to twenty inches. In so far as hitherto developed, the best ore and the thickest part of the veins have occurred within fifty feet of the surface. On the vein first worked the shaft has been sunk ninety feet, and ten tons of ore sent to market. At the second the shaft is two hundred feet deep, and drifts have been carried to the aggregate length of four hundred feet; ore to the amount of one hundred tons was obtained, of which thirty tons have been sold. At the third, which was in operation at the time of my visit, the shaft is sunk two hundred and eight feet, and seventy or eighty tons of ore had been obtained, some of which was said to contain a considerable proportion of silver. I must add that two specimens taken by me, for assay by Dr. Hunt, have shewn no traces of silver, although this may be no conclusive proof that it does not exist in some part of the vein.

Molybdenum.

In the account which I have given of the section of rocks exposed on the South-west Miramichi, I have mentioned the occurrence, near the mouth of Burnt Hill Brook, of sulphuret of molybdenum in thin quartz veins in gneiss. Some of the veins at the surface are charged with the mineral in thin foliated hexagonal plates. This mineral has found some important applications in the arts, chiefly for the production of a dyeing material and as a re-agent in the laboratory. It is somewhat rare, and the price was quoted in the Paris Industrial Exhibition of 1855 at \$3.45 per lb., (see *Geology of Canada*, p. 755). It is doubtful, however, if any of the veins visible at the surface at the locality named, which is remote and not easily accessible, will yield a sufficient quantity of the mineral to repay the cost of mining and sending to market.

Copper.

About three miles below the town of Woodstock, on the right bank of the St. John, veins of yellow sulphuret of copper, associated sometimes with much iron pyrites, occur at several points in the vicinity of an apparently stratified mass of rock resembling diorite, but holding a small proportion of quartz. These veins have attracted attention from a very early date in the history of the Province, and have formed the object of mining enterprise on a considerable scale, but were abandoned several years ago as unprofitable. The veins opened, though tolerably promising at and near the surface, were not found to maintain that character in sinking. In the rock cutting on the railway, about a mile below Woodstock, is a bed of light green or grey highly altered epidotic slate, con-

formable with the stratification, and resembling that near the Iron Works, in contact with which is a band of chloritic slate charged with iron pyrites and galena, and near to this a conglomerate similar to those formerly described as seen at the mouth of the Meduxnakeag. I found among the shingle on the bank of the river St. John, seven miles below Woodstock, a large boulder of rich copper pyrites in a matrix of slate conglomerate. Although, so far as yet known, the copper ore in the vicinity of Woodstock does not occur in true veins, masses of the character described, when of sufficient magnitude and richness, have been profitably worked in other parts of the world, and such may yet be brought to light here.

The iron ore of Jacksontown, three and a-half miles north-west from Woodstock, has attracted much attention from an early period, having been first noticed by Dr. Jackson in his Report on the Geology of Maine, 1837, and has been treated at various times in the smelting furnaces at Upper Woodstock, about the same distance from the mines. The ore is an impure slaty hematite, containing on an average 46 per cent. of the peroxide of iron, equivalent to 32 per cent. of metallic iron; it also contains a variable proportion of oxide of manganese, to which the iron probably owes some of its peculiar qualities. It occurs irregularly imbedded in red and green clay slates, and it is thus impossible to assign any specific or definite thickness or length to the deposits; enough, however, is known to justify the assertion that the ore may be found in very great abundance. That hitherto obtained, which has been extracted altogether by the method of open cuttings, and smelted at the Woodstock Iron Works, amounts to about 40,000 tons; many of the bunches of ore have been worked out at a depth of from twelve to twenty feet from the surface; some, however, seem to be connected with beds or courses, probably of greater regularity and continuity and of richer quality. In one of these (Carnie's mine), where much quartz was associated with the bed, and some of the ore was of the specular variety, I found small portions of purple copper ore.

The pig-iron produced from the Jacksontown ore is remarkable for its great hardness and strength, and when mixed in certain proportions with other kinds, has been found very advantageous for railway car-wheels. When converted into wrought iron, it is said, on the authority of Mr. Fairbairn of Manchester, to be specially suited for the plating of iron-clad war vessels and similar purposes, where a combination of great hardness and tenacity are requisite; it is also said to be admirably adapted for the manufacture of steel. The fuel used for smelting the ore at the furnaces, which were not, however, in operation at the time of my visit, is wood charcoal; of which 126 bushels, together with about $3\frac{1}{2}$ tons of ore, were consumed to make one ton of pig iron. The cost of the fuel and the somewhat low produce of the ore have hitherto retarded the vigorous prosecution of an undertaking which otherwise seems to possess the elements of success.

Similar ores occur, apparently in the same band of rocks, and in great abundance, near the River Beccaguimic, and also, although probably not so abundantly, in a parallel band running from Flanigan's Hill on the St. John, toward East Glassville settlement. If found economically available in other respects at either of these places, they will possess an advantage in the proximity of forests, from which a supply of fuel could be derived.

Gypsum and
limestone.

The deposits of limestone and gypsum on the Tobique, already described, are practically inexhaustible and easily accessible; and although their colour, and the admixture of foreign constituents might render them unsuitable for building and decorative purposes, they are well adapted for use in agriculture. These deposits are in the supposed Lower Carboniferous rocks. At several points also in the calcareous slate band between Woodstock and the Tobique, as at Pole Hill, Windsor and Glassville settlements, the bank of the St. John River in Peel parish, and two and a-half miles up the Tobique, bands or more or less extensive lenticular masses of limestone, sometimes fossiliferous, occur, which may advantageously be burnt in kilns, and employed for general purposes. As a flux for the smelting of iron ore, that from Pole Hill has been quarried and conveyed to the Woodstock furnaces; but I understand that the deposit on the St. John River in Peel, about four miles above the Beccaguimic, which has latterly been employed, is preferred, as it is said to contain less magnesia than the former.

The geological conditions in the north-western part of New Brunswick, being by many supposed to be analogous to those of auriferous countries generally, and more particularly of Eastern Canada and Nova Scotia, it is not surprising to find that, from an early period, hopes and expectations should have been entertained that it might prove a gold-bearing region, and these have been from time to time confirmed by reported actual discoveries of the precious metal.

Within the past two years, and since the Canadian and Nova Scotian gold mines have begun to attract increased attention, attempts have been made on a small scale, both by alluvial washings and by explorations in the supposed gold-bearing rocks, to realize these hopes. The results in both cases, so far as I have had the means of judging, are moderately encouraging; but it would require the expenditure of a larger amount of capital than has hitherto been applied in order to establish the *profitably auriferous* character of the region. In the few places where sluicing has been tried, and that only on a rude and tentative scale, the conditions appear to have been unfavourable, owing either to the absence of the older drift clays, which are supposed to be more especially gold-bearing, or to their being too far below the drainage level to be accessible without special and expensive appliances for pumping, etc.

With regard to gold in the rocks, although rumours are current on

respectable authority to the effect that pebbles and boulders enclosing a little of the metal have been picked up in various localities, I am not aware of any well authenticated instance of gold being found in a vein. On the Serpentine and Campbell rivers, and on the Wapskehegan, tributaries of the Toibque, where the rocks are supposed to be more especially favourable to the existence of gold, and where chiefly the auriferous pebbles are reported to have been found, mining leases have been taken up, but very little work done. I made a cursory examination of part of the lands leased for gold mining on the Serpentine; and although the rocks, as I have described them in another place, seemed to be of a favourable nature and condition, specimens of quartz which I took from what were considered the best spots here, as well as from several other places which I deemed worthy of trial, have yielded to careful assays by Dr. T. Sterry Hunt, neither gold nor silver.

The conditions both of the rocks and veins here appear to me to resemble those in the Chaudière district in Quebec, where the quartz veins are lenticular, interrupted, and only in exceptional cases yield gold; rather than those in the gold districts of Nova Scotia, where they are more regular and persistent, and very generally auriferous to a greater or less extent. The fact that no gold has been found in the specimens taken by me, by no means militates against the possibility of its being found in other specimens and at other localities in the region.

I have the honour to be,

Sir,

Your most obedient servant,

CHARLES ROBB.

REPORT

OF

T. STERRY HUNT, LL.D., F.R.S.,

CHEMIST AND MINERALOGIST,

ADDRESSED TO

SIR WILLIAM E. LOGAN, F.R.S., F.G.S.,

DIRECTOR OF THE GEOLOGICAL SURVEY OF CANADA.

MONTREAL, November 1, 1869.

SIR,—The subjects embraced in the Report which I have now the honor to submit to you, have already been mentioned in your summary Report to the Government, dated May 1, 1869, and are still farther indicated in the table of contents prefixed to the present volume. They include :

- I. Investigations into the geology and chemistry of the salt deposit of the Goderich region, and a discussion of the best modes of manufacturing salt, considered with reference to our own resources.
- II. Studies upon the iron ores of the Dominion and the best modes of working them. These investigations it is proposed to continue in a subsequent Report.
- III. Mineralogical notes on the occurrence of gold, silver and bismuth ores in Hastings county, with analyses.

I. THE GODERICH SALT REGION.

In the Report which I had the honor to submit to you in 1866, there will be found, on pages 263-272, an account of the salt deposit then recently discovered by boring, at a depth of 1,000 feet from the surface, near the town of Goderich, in Ontario. As regards its geological position, it was there shewn from the results of the boring that the Onondaga formation attains in that region a thickness of about 1,000 feet, of which the lower 200 feet consist of reddish and bluish shales, including beds of gypsum, and near the base a layer of rock salt, which in the Goderich well was said to have a thickness of about forty feet, including some layers of blue clay. From this depth there was obtained, by pumping, a saturated

AL SURVEY OF CANADA.

ch was given. Attention was in this Report and the remarkable purity of the brine, and ven to show its great superiority over the brines nd of Syracuse in New York. A table show- f different specific gravities, and the number of el of salt, was also given in this connection. It r, to give in the present Report a more extended h is reprinted from Professor Alex. Winchell's ichigan, published in 1861.

that Report, the well then described, which npany, has been constantly pumped, and large manufactured from the brine. Encouraged by eral other borings have been sunk in the imme- ling brines like the first one. The record of the same as that of the first. The presence of een established by the grains of salt brought up borings. In the course of 1867 Mr. Ransford teen miles to the south-east of Goderich, on the ke Huron railway, and was rewarded by the ng stratum, offering, it is said, a thickness of The depth of this well is 1180 feet, and the verlying the salt at Clinton is due to the south- ; from which it results that the summit of the h appears at the surface at Goderich, is at 200 feet of the Corniferous limestone. This es, to the north of Goderich, a broad triangular ard nearly forty miles, and bounded to the north- out-crop of the underlying Onondaga formation. eardine, thirty miles north-east of Goderich, rear, and showed the existence of the salt-bearing 900 feet. The record of the boring furnished

	<i>Fl. In.</i>
.....	91 6
.....	508 6
.....	23 0
.....	117 0
.....	30 0
very soft.....	125 4
.....	13 8
	<hr/>
	909 0

By comparing the above result with that obtained in the first well at Goderich, it will be seen that while the amount of shaly strata from the base of the limestone to the bottom of the salt was only 205 feet at Goderich, it attains at Kincardine a thickness of 309 feet; in which, however, are included thirty feet of a rock described as limestone, but which may perhaps be gypsum, masses of which were encountered in the shales in boring at Goderich. Of the 775 feet of limestone belonging to the formation at Goderich only 508½ remain at Kincardine, the upper portion being removed by erosion. It is not, however, certain that the original thickness of the Onondaga, or Salina formation as it is sometimes called, was precisely the same here as at Goderich, and thus the amount which has been removed by erosion may be somewhat greater or less than would at first appear. In like manner, the thickness of the same formation at Clinton may differ somewhat from that at Goderich, so that the overlying portion of Corniferous limestone at that place may be greater or less than 200 feet, according as the volume of the Salina formation is less or greater than at Goderich. Careful examinations of future borings would enable us to determine these important points, and for this end samples of the material extracted at intervals of fifteen or twenty feet, should be carefully preserved.

The base of the Onondaga formation comes to the surface at the mouth of the Saugeen river. Here, at Southampton, an ill-advised attempt was Southampton. last year made in search of salt by boring. According to the record furnished me, the solid rock was only reached at a depth of 230 feet,* after which 350 feet of white and gray limestone had been penetrated up to August 22, 1868. The subsequent record is incomplete, but beneath the limestones were encountered several hundred feet of red shales, and the boring was finally abandoned at a depth of 1,251 feet from the surface. Another well also was sunk last year at Port Elgin, five miles below South- Port Elgin. ampton, on the coast, and the boring in November last, had attained a depth of 890 feet, and was still going on in the red shales. In this connection may be noticed a well which was sunk in 1867, at the village of Waterloo, about eighty miles to the south-east of Port Elgin, but in the Waterloo. same geological position, that is to say near the base of the Onondaga

* The account of this portion of the boring is as follows:—

Gravel and sand, with trunks of trees at the base.....	23½	Feet.
Hard-pan and boulders.....	36	
Blue clay.....	5	
Coarse sand and gravel.....	16	
Hard-pan and boulders.....	4½	
Soft marly beds.....	50	
Blue clay with boulders.....	67	
Hard-pan and boulders, with gravel.....	28	

formation, and was abandoned at the depth of 1,120 feet. The record of the boring was as follows :—

Superficial clays and gravels*.....	130 Feet.
Limestone.....	40
Gypsum.....	17
Shale.....	20
Limestone, gray and white.....	340
Blue shale.....	114
Red shale.....	459
	1120

bitter water.

At this depth the well was abandoned ; bitter saline waters were met with at depths of 800 and 900 feet, and were probably similar to the bitter water found at St. Catharines at the same geological horizon. In the Report for 1866, on pages 271, 272, the waters of this class are noticed, and their unfitness for the manufacture of salt pointed out. The 77 feet of limestone, gypsum and shale in the Waterloo section belong to the base of the Onondaga, or salt-bearing series, beneath which no valuable brines have yet been found. The 340 feet of limestone underlying the shale, represent the Guelph, Niagara and Clinton formations, and the red and blue shales beneath these belong to the Medina formation. By referring to the account of a boring at Barton, near Hamilton, it will be seen that these shales have there a total thickness of about 600 feet. (Report for 1866, page 251).

Onondaga and
other rocks.

It will be noticed that the Onondaga formation, as shewn in the borings of Goderich and its vicinity, consists of several hundred feet of limestone, chiefly magnesian, underlaid by two or three hundred feet of red and blue shales, which carry rock-salt at their base. These are succeeded, in descending order, by the magnesian limestones of the Guelph, Niagara and Clinton formations, which rest upon the red shales of the Medina, as seen in the Southampton and Waterloo borings. We have the following succession in going downwards :

1. Limestones of the Onondaga or Salina formation.
2. Red and blue shales of the same.
3. Limestones of the Guelph and Niagara formations.
4. Red and blue shales of the Medina formation.

mistaken in
boring.

On account of the resemblances in color between the upper and lower couples of the above series mistakes may easily occur, as at Southampton, where the strata of 3 and 4 were supposed to be those of 1 and 2. Such errors, which have caused the expenditure of considerable sums of money at Southampton, Port Elgin and Waterloo, would be avoided by a careful

*For a notice of the superficial deposits of this region, see the *Geology of Canada*, page 897.

study of the distribution of the various geological formations of this region, as described in the *Geology of Canada*. The accuracy with which the limits of the various formations throughout this region were traced out by Mr. Alex. Murray, has received repeated confirmation in the course of the various explorations for oil and salt which have been made within the past few years.

As regards the possible extent of the salt-bearing area now under consideration, I take the liberty of quoting the following passage from my Report for 1866, page 271 :—

Extent of salt basin.

“With regard to the probabilities of obtaining salt wells by other borings in this region, it is to be remarked that the thickness of the deposit of salt traversed in the Goderich well may warrant us in expecting that its area may be considerable; though whether its greatest extent will be inland, or beneath the waters of the lake, can only be known by experiment. It has already been explained that salt deposits have been formed in basins whose limits were determined by the geographical surface at the time; and it is worthy of remark that both here and in New York the salt deposits are connected with a thickening of the Onondaga formation, which, in its thinner intermediate portion, is apparently almost destitute of salt; a fact suggesting former geographical depressions, in which the two salt-bearing portions of the formation may have been deposited. Although it would be unsafe to predict that this development of salt at the base of the Onondaga formation is so widely extended, its thickness at Tilsonburg, St. Mary's, London, and Enniskillen, is such that it seems probable that farther borings in these localities, where deep wells have already been sunk, may reach saliferous strata capable of yielding valuable brines.”

In confirmation of the first portion of the above extract, we can now point to the existence of salt at Clinton, thirteen miles to the S. E., and at Kincardine, thirty miles N. N. E. of Goderich. These two stations are forty miles apart, and a line connecting them would pass about seven miles to the east of Goderich. It is, therefore, extremely probable that the whole region between Clinton and Kincardine will be found underlaid by salt, and may belong to a single basin, whose extent yet remains to be ascertained.

The success of the borings at Goderich and in its vicinity has, as we have seen, led to the sinking of wells for brine, below the salt-bearing horizon. At the same time, other trials have been made in the hope of reaching it, by boring through rocks overlying those of the Goderich region. For the information of inquirers, it may therefore be well to recall briefly some of the facts with regard to the nature and thickness of these rocks, of which the details are given in my Report for 1866. It will there be seen that the most recent rocky strata in south-western Ontario are the

Portage formation.

greenish sandstones of the Portage formation. These pass downwards into hard black slates (the so-called Genessee slates) which, in their turn, rest upon the soft gray strata of the Hamilton formation. This group of sandstone and hard shale, which appears at the surface at Kettle Point in Bosanquet, and also in Warwick, is generally concealed by the clays of the region; but from the records of numerous borings, chiefly made in search of petroleum, we have been enabled to determine its thickness in many places. Thus, in a boring at Coranna, on the St. Clair river, near Sarnia, it measures 213 feet; in two borings in Camden, 146 and 200; in Sombra, 100; in Alvinstone, eighty feet; in Warwick, and near Wyoming station, about fifty; a little north of Bothwell, about eighty; and further south, towards the shore of Lake Erie, about sixty feet in thickness. It will be understood that this varying thickness is due to the erosion along the anticlinals, before the deposition of the clays, so that in many parts of the region only the lower portions of the black slates remain, while in other places they are entirely wanting.

Hamilton formation.

The hard strata just described are conformably underlaid by those of the Hamilton formation, which in some parts of New York attains a thickness of 1,000 feet, but is reduced to 200 feet in the western part of the State. It consists, in Ontario, chiefly of soft gray marls, called soapstone by the well-borers, but includes at its base a few feet of black beds, probably representing the Marcellus shale. It contains, moreover, in some parts, beds of from two to five feet of solid gray limestone, holding silicified fossils, and in one instance impregnated with petroleum; characters which, but for the nature of the organic remains, and for the associated marls, would lead to the conclusion that the underlying Corniferous limestone had been reached. The thickness of the Hamilton formation varies in different parts of the region under consideration. From the record of numerous wells in the south-western portion it appears that the entire thickness of soft strata between the Corniferous limestone below and the black shale above, varies from 275 to 230 feet, while along the shore of Lake Erie, it is not more than 200 feet. Further north, in Bosanquet, beneath the black shale, 350 feet of gray shale were traversed in boring, without reaching the hard rock beneath; while in the adjacent township of Warwick, in a similar boring, the underlying limestone was reached 396 feet from the base of the black shales. It thus appears that the Hamilton shale (including the insignificant representative of the Marcellus shale at its base) augments in volume from 200 feet on Lake Erie to about 400 feet near to Lake Huron.

Corniferous formation.

The Hamilton formation, as just defined, rests directly upon the solid non-magnesian limestones of the Corniferous formation. The thickness of this formation in western New York is about ninety feet, and in south-

eastern Michigan is said to be not more than sixty, although it increases in going northward, and attains 275 feet at Mackinac. In the townships of Woodhouse and Townsend its thickness has been found to be 160 feet; but for a great portion of the region in Ontario underlain by this formation, it is so much concealed that it is not easy to determine its thickness. If we may conclude from the boring at Clinton, it would seem to be in that locality not far from 200 feet. In the numerous borings which have been sunk through this limestone, there is met with nothing distinctive to mark the separation between it and the limestone beds which form the upper part of the Onondaga or Salina formation, and consist of dolomite, alternating with beds of a pure limestone like that of the Corniferous formation. The saliferous and gypsiferous soft magnesian marls, which form the lower part of the Onondaga formation are, however, at once recognized by the borers, and lead to important conclusions regarding this formation in Ontario.

At Tilsonburg, a boring showed the existence of the Corniferous limestone directly beneath about forty feet of clay, while in another boring, about two miles to the south-west, it was overlaid by a few feet of soft shales, probably forming the basis of the Hamilton formation. The first boring at Tilsonburgh, as mentioned in the report for 1866, was carried to a depth of 854 feet in the solid rock. Numerous specimens of the borings from the first 196 feet, were of pure non-magnesian limestones, but below that depth similar limestone alternated with dolomite. The marls which occur at the base of the Onondaga formation were not met with in this boring, though the water from 854 feet was said to be strongly saline. I was informed by the proprietors, Messrs. Hebbard & Avery, that the well furnished, by pumping, a brine marking from 35° to 50° of the salometer, but I was not able to get any of the water, and the well was soon after abandoned, although the presence of so strong a brine would seem to show the proximity of a saliferous stratum.

In a boring at London, where the presence of the base of the Hamilton was marked by about twenty feet of gray shales, including a band of black pyroschist, overlying the Corniferous, 600 feet of hard rock were passed through before reaching soft magnesian marls, which were penetrated to the depth of seventy-five feet. Specimens of the borings from this well, and from another near by, carried 300 feet from the top of the Corniferous, show that pure limestones are interstratified with the dolomites to a depth of 400 feet. At Tilsonburg a pure limestone was met with at 524 feet from the top.

At St. Mary's, 700 feet, and at Oil Springs in Enniskillen, 595 feet of limestone and dolomite were penetrated, without encountering shales; while in another well, near the last, soft shaly strata were met with at

is not less than 414 feet below the surface-level of Onondaga Lake, and 50 feet below the sea level.—(Trans. N. Y. State Agricultural Society, 1859.)

Beds of the ancient gravel are occasionally found converted into a hard concrete, the cementing material of which, in some cases at least, is crystalline laminated gypsum. The wells are bored in this gravel to various depths up to 350 feet; brine is met with at about 100 feet, but the brines of the deeper wells are stronger, and less liable to variations in quality with the season of the year.

The report of the superintendent of the Onondaga salt springs, for 1868, Salt wells. contains some interesting details of wells sunk in this region during the preceding year. One of these, at a distance of two or three hundred yards from the wells which supply with brine the Liverpool district, was found to be outside of the gravel basin, the green shales of the Onondaga formation having been encountered at a depth of 82 feet, beneath which the strata, to a depth of 715 feet from the surface, consisted of green, red and gray shales, with a few beds of bituminous limestone, and a little gypsum, green shales forming the base. Fresh water was met with at 116 feet, and salt water first appeared at 164 feet. Analysis of the saline waters, from 291 and 540 feet, are given by Dr. Goessmann. That from the latter depth contained in 100 parts, chlorid of sodium, 4.5478; chlorid of calcium, 5.8658; chlorid of magnesium, 2.0237; sulphate of lime, 0.1070=12.5433. The water from the higher level contained nearly the same proportions of elements, but was less strong. The water from a well 148 feet deep in the shales, four miles farther west, was very similar in composition to that of which the analysis has just been given, and the same is true of two wells sunk in 1867 at Canastota, about twenty miles to the eastward of Syracuse.

In one of these, after penetrating through about 300 feet of red and Canastota. blue clays, a cemented gravel was met with, followed by loose gravel and sand to a depth of not less than 648 feet, where a hard rock was encountered, and the boring discontinued. The water from these wells was a strong but bitter brine containing in 100 parts, sulphate of lime, 0.0058; chlorid of calcium, 4.8200; chlorid of magnesium, 0.9281; chlorid of sodium, 15.2288, and carbonate of iron 0.0150. For this analysis and description of the well I am indebted to Dr. C. A. Goessmann. Here, then, as at Syracuse, the brine occurs in a deep excavation in the Onondaga formation. The shales of this region, as long since pointed out by Eaton, show, in many parts, peculiar hopper-shaped markings, which are recognized as the casts of crystals of chlorid of sodium, and hence it was conjectured that the source of the brines was to be found in these strata; Source of brines. although it was not impossible that they might be derived from more

recent deposits of rock salt occupying the remarkable gravel-filled basins which are shown to exist at Syracuse and Canastota. The discovery, in Ontario, of rock-salt in solid masses interstratified with the base of the Onondaga formation, leaves, however, but little doubt of the correctness of the views long maintained by the New York geologists, that the source of the brine is to be found in this formation. Borings like those of Goderich will probably one day show the existence in the vicinity of Syracuse of similar beds of rock-salt which now yield to the action of infiltrating waters the brines that accumulate in the gravel beds occupying the reservoirs just described. These also receive the bitter waters which are derived from the shales of the same formation, and contaminate the brines of Syracuse; although they do not mingle to any injurious extent with the water from the borings of Goderich and its vicinity.

Port Austin,
Michigan.

In this connection it may be mentioned that brine has been obtained at Port Austin, Huron County, Michigan, on the opposite side of the lake and a little north of west from Goderich. The surface rock of this region is a sandstone of the Chemung formation, beneath which, at a depth of 1198 feet from the surface, there was extracted a brine of which a specimen furnished to Dr. Goessmann marked 88° of the salometer, and gave for 100 parts, chlorid of sodium, 17.6161; chlorid of calcium, 3.1274; chlorid of magnesium, 1.5675, and sulphate of lime 0.0129 = 22.3239. The thicknesses of the different formations across this western region, from New York to Michigan, are well known to be very variable, and it is impossible, with our present data, to say at what depth the Onondaga formation should be found at Port Austin; but the occurrence there of a brine at 1198 feet would indicate either a considerable diminution in the volume of the strata between the base of the Onondaga and the Chemung, or the existence of a saliferous horizon in the Devonian strata, and consequently intermediate between the Onondaga formation and the Michigan salt group, which is situated at the base of the Carboniferous limestone in that State. In the vicinity of Lake Huron, in Ontario, the Onondaga has a thickness of 1,000 feet, the Corniferous probably about 200, the Hamilton very nearly 400, while the Portage group is represented, both near Sarnia and in the adjoining state of Michigan, by more than 200 feet, making thus 1800 feet from the base of the Onondaga to the summit of the Portage formation. (Report for 1866, p. 241-250.) The above facts with regard to salt in Michigan and New York, are worthy of being put on record, as they may be found to have, in more ways than one, an important bearing on our own salt deposits. Some are private communications of C. A. Goessmann, Ph. D., now professor of chemistry at Amherst, Mass., but for several years chemist to the Onondaga Salt Company. His published papers on the Onondaga brines in the *American Journal of Science* for 1866, [2] XLII.,

Goessmann's
researches.

211, 368, have also been consulted, and various pamphlets and reports by him will be frequently cited in the course of this Report. I take this occasion to express my deep sense of the value of his important contributions to the chemistry of salt-making in New York, and of the courtesy with which he has aided me in my inquiries into the salt manufacture at Syracuse. He has also visited the Goderich region and submitted the brine to analysis.

ANALYSES OF THE BRINES OF GODERICH AND ITS VICINITY.

In the Report for 1866, a first analysis was given of the brine extracted from the well of the Goderich Company, the first one bored at Goderich, and at that time not yet pumped in a continuous or regular manner. Since that time the well has furnished an uninterrupted supply of salt water, and has yielded, for the greater part of the time, 100 bushels of salt daily. It becomes therefore an interesting inquiry whether, during this period of more than two years, the composition of the brine has undergone any change, and to this end we may compare four analyses made from brines taken at the dates given below, the analysis II. being by Dr. Goessmann, the others by myself:—

- I. August 19, 1866; cited from Report for 1866, page 269.
- II. April 1867; from a Report by Dr. Goessmann.
- III. February 1868; brine sent me by the proprietors of the well.
- IV. November 5, 1868; brine collected by me at the well.

	I.	II.	III.	IV.	Analyses.
Chlorid of sodium.....	259.000	241.433	undet.	236.410	
“ “ calcium. ....	.432	.216	.182	.190	
“ “ magnesium. ....	.254	.336	.288	.410	
Sulphate of lime.....	1.882	5.433	.5679	4.858	
	<u>269.568</u>	<u>247.418</u>	<u>.....</u>	<u>241.868</u>	
Specific gravity.	1.205	1.195	1.192	1.187	
Degrees of the salometer.	100°	95°	94°	92°	

[The cause of these variations is to be found in the fact that the sources of saline matters in these brines are three-fold: 1st. The solution of nearly pure rock-salt; 2nd. The solution of beds of gypsum or sulphate of lime, which lie in the shales above the salt; and 3rd. The intermixture of bitter waters, containing large proportions of chlorids of calcium and magnesium. Such waters occur in the strata both above and below the salt deposit, and become mingled with the fresh waters which flow in to supply the void caused by pumping. The composition of these bitter waters is very variable; in some the chlorid of calcium and in others the chlorid of magnesium predominates. The waters of this class are noticed in connection with salt-making

in the report just cited, page 271, and analyses are given on pages 272, 273 and 276. The analysis of a similar water from Syracuse is given in the present report on page 219. The quantity of bitter salts in the Goderich brines, however, is insignificant when compared with those of most other salt-producing regions. It is to be noticed that at the time of the first analysis, the well was not regularly pumped, and that the brine, though saturated, contained less gypsum and more chlorid of calcium than it has since yielded; while the chlorid of magnesium has somewhat increased in quantity. The density of the brine is subject to some little variation, but is said in the Goderich Company's well rarely to fall below 92°, and after a repose of a few hours to rise considerably above it. Of the other wells which have been sunk at Goderich, four were being pumped at the time of my last visit, in November, 1868, and from these I took specimens of brine. It was not considered necessary to analyse these brines from adjacent wells of the same depth, but their specific gravity at 62° F. was determined, and is here given, with the corresponding degree of the salometer:—

Goderich Company's well,	density	1.187	equal	92°	salometer.
Dominion well,	"	1.175	"	87°	"
Huron well,	"	1.176	"	87°	"
Ontario well,	"	1.160	"	81°	"
Victoria well,	"	1.160	"	81°	"

The brines of Clinton and Kincardine shew a strength and purity comparable to those of Goderich. Of the following analyses, V is that of the brine from the Clinton well, collected by me on the 6th November, 1868, and VI is that from Kincardine, sent to me by the proprietor a few days later, the well not having been in operation at the time of my visit to the district:—

	V.	VI.
Chlorid of sodium.....	204.070	241.350
" " calcium.....	.470	.840
" " magnesium.....	.184	.230
Sulphate of lime.....	5.583	3.264
	<hr/> 210.307	<hr/> 245.484
Specific gravity.....	1.157	1.191
Salometer.....	80°	94°

MANUFACTURE OF SALT AT GODERICH AND CLINTON.

Of the wells above mentioned, that of the Goderich Company has been regularly worked since October, 1866, and the manufacture of salt was commenced at the four others named above, the Dominion, Huron, Ontario, and Victoria wells, during the summer months of 1868. In November

last, the boring of three others was nearly or quite completed. Two of these, called the Prince and Maitland wells, are, like that of the Goderich Company, on the north side of the Maitland River, while a third, the Tecumseh well, is on the south side, near the others mentioned above. The number of kettles used, and the daily produce of the wells then in operation was, in November, 1868, stated to be as follows:—

Goderich Co,	104 kettles.	yielding 100 barrels of salt.
Dominion,	60 "	" 55 "
Huron,	120 "	" 110 "
Ontario,	60 "	" 55 "
Victoria,	60 "	" 55 "
	<hr/> 404 kettles	<hr/> 375 barrels.

The Goderich Company and Huron wells have two blocks of kettles each, the others but one, the block of kettles consisting of two parallel rows of from twenty-six to thirty cast-iron kettles each. The arrangement is copied from the works of the Onondaga Company, at Syracuse, New York, where the number of kettles in a block varies from fifty to sixty. The capacity of the kettles used at Goderich varies from 120 to 140 gallons, the larger ones being placed towards the front, and exposed to the greater heat, from which, however, they are partially protected by arches constructed under the first nine or ten kettles. At Syracuse, in some of the blocks, the rear kettles have a capacity of not more than 100 gallons. The cost of a block of sixty kettles at Goderich is said to be \$1,500, to which is to be added for the construction of the furnace, \$1,600, making a total of \$3,100.

The fuel hitherto used at Goderich has been chiefly wood, which costs there \$2.50 the cord. Bituminous coal, which has been tried there to a small extent, is shipped from Cleveland, and delivered at Goderich, as I was informed, for \$3.80 the ton. The amount of salt to be obtained by the use of a cord of wood, at Goderich, was variously estimated by the different salt-makers. The figures furnished me by Mr. Samuel Platt, which seem to be the result of careful observations at the Goderich Company's works, give a consumption of sixteen cords of hard-wood for one hundred barrels, of five bushels each, of salt. Of this amount of wood one and a-half cords are consumed for the engine employed in pumping the brine, leaving fourteen and a half cords for the evaporation, which gives about 34½ bushels to the cord of wood. The estimates at two other wells, given me by persons worthy of confidence, corresponded respectively to 35½ and 36 bushels to the cord, and we may therefore, I think, assume 35 bushels of salt, of 56 pounds each, to be the average result for the cord of hard-wood employed at Goderich.

Fuel: coal and wood.

Salt boiling.

Salt works.

GEOLOGICAL SURVEY OF CANADA.

At Syracuse, where wood is also used to a considerable extent, the cost of salt is from 37 to 38 bushels to the cord of wood, and the ton of wood gives about the same amount, so that in round numbers the production of a pound of salt there, requires the combustion of a pound of coal ($37 \times 2072 \text{ lbs.}$) The cost of coal delivered to the salt-makers at Syracuse was, in 1868, \$8.50 American currency. The wood used there by some of the manufacturers is cut from lands in the vicinity. From the figures, which I received at Syracuse from what I consider a reputable authority, it would seem that the salt-makers of Goderich will be gainers by the attempt to substitute imported coal for the wood of their own neighborhood, since, while the cord of wood is equal in salt-producing power to a ton of coal, its cost in round numbers, is, at present, only two-thirds as much.

The brines of Syracuse mark from 59° to 65° of the salometer, while those of Goderich, as seen above, give from 81° to 90° and even 95° . A brine of 60° contains 15.6 per cent. of salt, and 38.9 gallons of it are required to yield a bushel of salt; while a brine of 90° holds 28.4 per cent., and yields a bushel of salt for 24.5 gallons. Hence it appears that, in round numbers, the Goderich brines contain about one-half more salt than those of Syracuse, or are fifty per cent. richer. So that, as remarked by Dr. Goessmann, we should expect fifty-two bushels as the yield at Goderich for the cord of wood, being an increase of nearly 50 per cent. on the now obtained.

This great discrepancy between what might be expected, and the results actually obtained at Goderich, is easily explained, and is found in the fact that the system of evaporation pursued at Syracuse, and adopted at Goderich, is one not suited to the strong brines of the latter region. On this point Dr. Goessmann remarks that the only difficulty with which the salt-makers of Goderich have now to contend "is the rapid incrustation of the kettles, a trouble due to the strong concentration of their brine, in connection with their peculiar system of manufacture." Under these circumstances, the salt separates in considerable amount in very fine particles, and a hard incrustation forms on the bottom and sides of the kettles, which soon becomes several inches in thickness. This not only causes a considerable waste of salt, since these crusts are not fit for market, but, what is of much greater importance, prevents the economical application of the fuel; besides which, the necessity of a frequent removal of the crust from the salt generally keeps one of each row of kettles out of service. The crust may be removed either by mechanical means, or by dissolving it out with fresh water, a process which involves the loss of time, fuel and salt. With the weaker brines, on the contrary, like those of Syracuse, the fresh supplies of brine added to the emptied kettles suffice to dissolve any exist-

ing crust, and the difficulties which cause such a serious loss at Goderich are not felt.

Dr. Goessmann proceeds, in describing the manufacture at Goderich :—
 “ The salt is, after separation from the pickle, (mother-liquor) as might have been expected from a brine like that of Goderich, of a superior color, of a hard fine grain, resembling the best brands of home and foreign manufacture, and this success is attained without any but the ordinary care required for the manufacture of common fine salt. It will be noticed that the sole objection which may be raised against the Goderich brine, is merely incidental, for the brine is too strong to be worked to its full advantage by the system of manufacture at present pursued. Evaporation by more moderate heat, for instance, on the European plan of large pans, or evaporation by solar heat in wooden vats, on the Onondaga plan, would, no doubt, prove more successful. Each of these methods would produce, with less trouble, not only a very good marketable article of its kind, but secure what is most important, the full percentage of salt, which might be expected, comparing its concentration with the brines of Onondaga, to be a difference of 50 per cent.”

Goessmann's
opinion.

The above extracts are from a printed Report by Dr. Goessmann, dated January, 1868, on the salt resources of Goderich. Since that time the system of evaporation in pans has been tried at Clinton, and the results fully justify the recommendation by Dr. Goessmann. The Stapleton salt-work here erected by Mr. Ransford, has two pans, each twenty-one feet wide by forty feet long, and fifteen inches deep. Under the front pan three wood fires are kept up ; the brine in this is maintained in rapid ebullition, while the waste heat passes under the second pan, in which a slower evaporation goes on, producing a coarse flaky salt. The daily production of these two pans was, I was informed, equal to fifty barrels of fine salt from the front pan and twenty barrels of coarser salt from the rear one, equal to seventy barrels, and the consumption of wood for this production was seven cords, being at the rate of fifty bushels of salt for the cord of wood. Although the brine was said to mark generally 85°, the specimen taken by me, whose analysis is given on page 221, was not above 80° ; the result thus shows most satisfactorily the greater economy of fuel to be attained by the use of pans, and the utilization of the waste heat, as practised at Clinton. The crust which forms on the first pan is removed once a week, and is found in that interval of time to be from one and a quarter to one and a half inches in thickness. But very little crust is deposited in the rear pan, except at the end nearest the fire. In Cheshire, in England, where brines as concentrated as those of Goderich are evaporated, pans similar in dimensions to those at Clinton are made use of ; while single pans, having a breadth of twenty by a length of forty feet, and a depth of two feet, are

Evaporation in
pans.

Clinton.

also employed, in which the evaporation is carried at temperatures as low as 150° Fahrenheit, for the production of coarse salt.

Platt's system. Mr. Samuel Platt, under whose superintendence the first salt was made at the Goderich Company's well, has patented an evaporating pan, to which the heat is applied by the means of steam heated to a pressure of thirty pounds. In this way it is expected to effect an important saving of fuel, and obtain other advantages. I have not yet learned the result of experiments in progress for the purpose of testing the merits of this system. Several other proposed improvements in evaporators have recently been made the subject of patents in Canada.

Purity of the brines. Attention was called, in the Report for 1866, to the great purity of the Goderich brines, of which Dr. Goessmann subsequently writes, in his report already cited: "The present brine of Goderich is not only one of the most concentrated known, but also one of the purest, if not the purest, at present

Earthy chlorids. turned to practical use for the manufacture of salt;" and he proceeds to remark that the proportion of obnoxious deliquescent chlorids (of calcium and magnesium) is from one-fourth to one-fifth of that found in the brines of Syracuse. It will be seen by referring to the table of analyses, given on page 221, that the proportion has not increased after more than two years pumping of the well first sunk; the only change being that the amount of gypsum has augmented. The earthy chlorids, just mentioned, being much more soluble than the salt, do not separate, but remain behind in the mother liquor, which should, from time to time, be emptied from the evaporating vessels. From a neglect of this it would otherwise happen that the salt would, after a time, be rendered impure from the adhering mother-liquors, and be reduced to the condition of salt manufactured from inferior brines like those of Saginaw; the impurity of which consists in these same earthy chlorids, which it becomes necessary to remove by a special process. The precaution of throwing out the mother-liquors from time to time, has not been attended to at Goderich; and when it is found necessary to empty a kettle for the purpose of removing the crust, it has been the practice to transfer the brine into an adjoining kettle. The effect of this is shown by the following comparative results for 100 parts of brine; A being the recent brine, marking 94°, whose analysis is given at III. on page 221, and B, a saturated brine, marking 100°, taken from one of the boiling kettles at the same time:—

	A.	B.
Chlorid of calcium.....	·182	·688
" " magnesium.....	·283	1·185
Sulphate of lime.....	5·679	4·908

The diminution in the amount of sulphate of lime is due to the fact that both heat and the presence of earthy chlorids diminish its solubility.

These latter salts are present in a four-fold proportion in the evaporated brine, showing clearly the accumulation of these which takes place when the common salt is removed, and the necessity of throwing out the old liquors from time to time.

In the brines of Saginaw, the chlorid of magnesium, which is more obnoxious than the calcium salt, is got rid of by the addition of a small portion of quick-lime, as described in the Report of 1866, page 265. On page 267 of that report will be found analyses of brines from other regions, that of Syracuse included, which, as we have seen, contains from three to four times as much of these bitter earthy chlorids as our own brines. These are decomposed by an ingenious process, which consists in washing the previously drained salt in a pure saturated brine, to which has been previously added a sufficient proportion of carbonate of soda to decompose the earthy chlorids present in the salt, the proportion being determined by the results of analysis. The salt purified by this operation is drained, and partially dried in bins, after which the drying is completed in hot-air chambers, or in revolving cylinders heated to 250°—300° F., and the salt finally screened and ground. This process yields the so-called "Factory-filled Salt" of Syracuse, greatly estimated for dairy use, of which about 700,000 bushels are manufactured yearly.

Purifying salt.

Factory-filled salt.

ON THE MANUFACTURE OF SOLAR SALT.

We have already referred to the advantages offered by Goderich for the manufacture of solar salt, and now propose to give a brief account of the system pursued for making it at Syracuse, New York, based upon published reports, and upon my own observations in 1868. The conditions in which the brine is met with in a gravel-filled basin of small extent on the shores of Onondaga lake, near to Syracuse, have already been described. The salt-producing area, known as the Salt Springs reservation, is divided into four manufacturing districts, known as the 1st, or Syracuse, the 2nd, or Salina, the 3rd, or Liverpool, and the 4th, or Geddes district. The wells in the Liverpool district became valueless and were abandoned in 1866, and the brine now required for the works at Liverpool is raised from the wells in the Salina district, and conveyed by a line of bored logs of nine inches calibre, to a reservoir seventy-five feet long, fifty-three feet wide, and eight feet deep. The large reciprocating pumps hitherto used are now being replaced by small rotary brass pumps, one of which, costing \$300 American currency, is said to be sufficient for the most abundant well.

Syracuse salt works.

The various salt-makers in these four districts, were in 1860, united into an incorporated company, known as the Salt Company of Onondaga. By

Onondaga Salt Co.

this union of their interests under one head they have been enabled to secure great advantages. Among these have been the appointing of agents in the principal markets of the country, the establishment of a general direction ensuring uniformity in the quality of the salt and the mode of preparing it for market, and finally the employing of a scientific chemist to direct the works, and, by careful studies, to suggest improved methods of manufacture.

Annual production.

These works pay to the state a tax of one cent per bushel, besides a rental, which is, however, insignificant, since it appears that the whole sum paid by the Company to the state in 1867, for rents and penalties, was only \$102; the duty amounting for the same time to \$75,956.06, being for 7,595,565 bushels of fifty-six pounds each, the amount inspected in 1867. Of this amount, 2,271,892 bushels were made by solar evaporation and 5,323,673 bushels by boiling. Of the solar salt, 308,266 bushels were ground, and of the fine or boiled salt, 188,866; of which 41,929 bushels, prepared in the Geddes district, are described as table-salt.

I am not able to give the entire number of blocks of kettles in the establishments of the Company; but it is stated in their report for 1867, that the average daily produce of salt for each block during the year was equal to nearly 261 bushels, while the average from the seven blocks of kettles at Goderich, from the figures given on page 223, was 268 bushels.

The cost of making solar salt in the Onondaga region is estimated to be a little less than that of boiled salt.

Solar-salt making.

The process of making solar salt at Syracuse is divided into three stages: First, the settling of the brine, as it is called; second, its concentration, or what is called pickle-making; and third, the making of salt from the pickle. The brine after being raised, is stored in reservoirs, from which it is led

Settling-rooms.

through bored logs to the deep-rooms or settling-rooms, as they are termed, where it is exposed to the air in large tanks, which are deeper than those used in the subsequent stages. There the brine absorbs a portion of oxygen from the air, by which means the carbonate of protoxyd of iron, which is dissolved in the recent brine, is converted into insoluble peroxyd of iron. This separates in a hydrated form, as an insoluble yellowish mud, which accumulates in the bottom of the tanks, and the brine becomes clear and colorless. This first stage is not required for our Goderich brines, which are free from any trace of iron.

Lime-rooms.

The process of evaporation, of course, begins in the settling room, but is continued in what are variously called lime-rooms, gypsum-rooms, or plaster-rooms, from the fact that the sulphate of lime or gypseum, (which is the same substance as uncalcined plaster of Paris) is here deposited in a hydrated state, and in the form of crystals, which in time nearly cover the bottoms of the vats. As the brine approaches saturation, flakes of gypsum are seen

Gypsum.

floating on the surface of the liquid, and at length the appearance of crystals of salt shows that the second stage of the process is accomplished, and that the saturated brine, known as salt-pickle, is ready for the third stage. This is then at once removed, and is ready for the salt-rooms, in which the deposition of the salt goes on.

By salt-rooms are meant areas occupied by the evaporating vats or Salt-rooms- covers, as they are called, which are provided with moveable roofs, that can be drawn over the covers in rainy weather, but withdrawn at other times, so as to expose the brine to the action of the wind and sun. The covers are rectangular in shape, and all of the same size, being sixteen by Salt-covers. eighteen feet, and six inches deep. They are raised on wooden supports two or three feet from the ground, and are arranged in sets or strings, each from four to six inches above the other, so that the liquid can be made to flow from the higher to the lower by opening small gates. The whole number in use at Syracuse in 1867 was 41,718; of these, in round numbers, two-fifths belong to the settling and gypsum-rooms, while three-fifths, or about 25,000, are salt-covers. The average yield for each cover at the Salt Company's works was, in 1867, 54½ bushels; while for the salt-covers, which are fed with saturated brine, it would, if we take their number to be 25,000, equal more than 90 bushels to the cover, for the season. With the purer and more concentrated brines of Goderich the settling tanks are unnecessary, and the time required in the gypsum-rooms to bring the brine to the condition of saturated pickle would be very much abridged, so that a much less proportion of the covers would be required for the gypsum-rooms, and the average production of salt to the whole number of covers, very greatly increased.

One of the conditions required for the production of a good large-
grained solar salt, which is most esteemed in the markets, is that the bot-
tom of the covers in the salt-rooms should be as smooth as possible; rough
surfaces favoring the deposition of numerous small crystals. It is also neces-
sary to have the salt-covers supplied with a sufficient supply of good pickle,
so that the salt already deposited may always be covered. An exposure
of the salt uncovered to the air favors the formation of new small crystals,
and the addition of an unfinished or not sufficiently concentrated pickle
produces the same effect, inasmuch as it brings an excess of sulphate of
lime into the salt-room; and the increased separation of gypsum will also
cause the production of a larger proportion of fine grains of salt. It is
also of great importance that the waste pickle, from which the greater
part of its salt has crystallized, should be removed from time to time, as its
presence not only impairs the quality, but diminishes the quantity of the
salt deposited.

Conditions for
working.

A correct understanding of the chemical relations of the various con-

**Chemistry of
brines.**

stituents of brines is so important to the manufacturer of salt that it is well to enter into some details on the subject, and to embody the result of a very careful and valuable series of experiments carried on by Dr. Goessmann at Syracuse, and published by him in a report to the Onondaga Company in 1864. In the Report of the Geological Survey for 1853-56, pages 404-419, I have described in detail the manufacture of salt by the evaporation of sea-water, and the chemical reactions which come into play in the process.* The composition of sea-water differs in some important particulars from that of brines like those of Syracuse and Goderich, and especially in the presence of a large amount of sulphates, so that the evaporated brine or salt-pickle from sea-water contains no chlorid of calcium and only a trace of gypsum, but besides a large proportion of chlorid of magnesium, a considerable amount of sulphate of magnesia.

**Their compo-
sition.**

The compounds found in native brines, like those of Goderich and Syracuse, are as follows: 1st, chlorid of sodium or common salt; 2nd, chlorid of calcium; 3rd, chlorid of magnesium; and 4th, sulphate of calcium or sulphate of lime. In addition to these, small portions of carbonate of iron are often present; this substance is separated at an early stage of the process, as already explained, in the form of hydrated peroxyd of iron, and unless carefully removed in the settling-tanks gives a reddish tint to the salt. This objectionable impurity is, however, entirely absent from the brines of Goderich and its vicinity. In addition to the substances already mentioned, the brines contain small portions of chlorid of potassium and of bromid of magnesium. These, however, have no perceptible influence on the manufacture of salt. The chlorids of calcium and magnesium, being compounds of what are sometimes called the earthy metals, are frequently spoken of as earthy chlorids, a term which, for convenience, will sometimes be made use of in discussing the relations of the various elements of brine to water and to each other.

Earthy chlorids.**Solubility of
salt.**

A saturated brine prepared with pure water and pure salt (chlorid of sodium) has a specific gravity about 1.205 at 60° Fahrenheit, (Liebig) and contains 26.423 per cent. of salt. The presence of earthy chlorids, however, diminishes the solubility of salt in water, so that a saturated brine containing these chlorids is less rich in salt than if it were pure. Another point to be considered in this connection, is that as these chlorids are much more soluble in water than the salt, the latter crystallizes out first, leaving them behind in the pickle, where they accumulate; the salt which separates retaining only so much of the earthy chlorids as is present in the pickle which moistens it. At length, after the separation of the greater part of the salt, either by boiling or by solar evaporation, the proportion of these

* See also the American Journal of Science for 1858, vol xxv. page 361.

chlorids becomes so great that they predominate in the pickle or mother-liquor, which becomes what is called bittern by the makers of salt from sea-water. It has a sharp and bitter taste from the presence of the chlorids of calcium and magnesium, and as these compounds have a great attraction for water, and even absorb it from moist air, when in concentrated solutions, it follows that the pickle from which the greater part of the salt has been separated no longer loses water by exposure to the air at ordinary temperatures, and although very dense, and marking a high degree on the salometer, holds but a small proportion of salt.

The sulphate of lime presents curious relations both to water and to the other compounds present in natural brines. 100.00 parts of pure water, at ordinary temperatures, dissolve about .25 parts of the sulphate of lime, but it is somewhat less soluble in water at the boiling point, and at higher temperatures becomes almost insoluble; a property which causes it to be deposited in high-pressure boilers in which sea-water and other waters holding this sulphate in solution, are exposed to temperatures much above 212° F. Sulphate of lime is much more soluble in a strong solution of salt than in pure water, while on the other hand the earthy chlorids diminish its solubility. Thus 100.00 parts of pure saturated brine are capable of holding in solution from .50 to .60 parts of sulphate of lime while in the bittern or pickle in which there has accumulated a large amount of earthy chlorids, the sulphate becomes nearly insoluble. Its solubility in brine, as in pure water, is also diminished by heat, so that a brine brought to saturation by boiling, deposits more of its sulphate of lime than if concentrated by evaporation at the ordinary temperature. These points are exemplified by the following series of analyses made by Dr. Goessmann with the especial object of throwing light upon the manufacture of solar salt at Syracuse.

Mother-liquor.

Sulphate of lime.

Goessmann's experiments.

I. Brine from one of the wells at Syracuse, having a specific gravity of 1.1225, which corresponds to 65° of the salometer at 70° F.

II. Pickle or saturated brine obtained by concentrating I by solar heat until it was ready to deposit salt. It then had a specific gravity of 1.2062, equal to 100° of the salometer at 70° F.

II A. An artificial brine, almost identical with the last, and prepared for certain experiments to be mentioned farther on.

III. Pickle "from the *first cover* of a string of salt-vats numbering from thirty to thirty-four covers. The latter were partitioned into two sub-divisions. The one towards the head of the string was from five to six inches higher than the one towards its termination."

IV. Pickle "from the *last cover* of the same string," the whole having been filled with new pickle for the season's work. The liquid flows from III down to IV, so that the latter represents a pickle which has parted with a considerable portion of its salt.

V. Pickle from the last cover or string of a similar series, at the middle of the summer season, when evaporation had proceeded so far that the pickle was low and the salt partly bare.

A comparison of the results given under II, III, IV, and V, will show that in these pickles, the proportion of sulphate of lime diminishes as that of the earthy chlorids increases.

	I.	II.	II A.
Sulphate of lime	0.5772	0.4110	0.4090
Chlorid of calcium.....	0.1533	0.2487	0.2687
Chlorid of magnesium.....	0.1444	0.2343	0.2578
Chlorid of potassium.....	0.0119	0.0194	0.0194
Bromid of magnesium.....	0.0024	0.0039	.....
Carbonate of iron	0.0044	.....	.....
Chlorid of sodium.....	15.5317	25.7339	25.6906
Water.....	83.5747	73.3488	73.3545
	<u>100.0000</u>	<u>100.0000</u>	<u>100.0000</u>

	III.	IV.	V.
Sulphate of lime	0.3188	0.1148	0.0264
Chlorid of calcium	0.4223	2.6959	10.4690
Chlorid of magnesium.....	0.6005	2.7513	10.5020
Chlorid of potassium	0.0194	0.0177	3.3769
Bromid of magnesium	0.0331	0.1160	0.4485
Chlorid of sodium.....	25.0462	20.1066	8.7441
Water.....	.....	.....	.....
	<u>100.0000</u>	<u>100.0000</u>	<u>100.0000</u>

In this connection Dr. Goessmann gives the following analyses, in which VI shows the proportion which the sulphate of lime and the earthy chlorids bear to the salt in the fresh pickle, II; and VII the average composition of the solar salt made from this pickle at Syracuse. These results show that only about one-eighth of the earthy chlorids present in the fresh pickle are retained by the salt, the remainder accumulating in the mother-liquor, except a small portion, which is supposed to pass through the pores of the wood.

	VI.	VII.
Sulphate of lime.....	1.5400	1.3378
Chlorid of calcium... ..	0.9335	0.0932
Chlorid of magnesium	0.8817	0.1200
Chlorid of sodium.....	98.6448	98.4490
	<u>100.0000</u>	<u>100.0000</u>

The composition of the old and half-exhausted pickles is shown in the analysis IV, and at a still later stage in V. The evils resulting from this accumulation of chlorids are many: first, the salt removed from these

is impregnated with a very impure pickle, which not only adheres to the crystals, but fills small cavities in them; the presence of these earthy chlorids being unfavorable to the production of solid crystals free from cavities. These adhering solutions of earthy chlorids never dry completely at ordinary temperatures, and keep the salt constantly moist, and very easily affected by damp weather. Again, these impurities affect the quantity as well as the quality of the salt produced, by retarding the process of evaporation. Under any circumstances the force of affinity causes such saline solutions as these to evaporate less rapidly than pure water, at ordinary temperatures. Thus it was found by Dr. Goessmann, on exposing equal volumes to evaporation under the same conditions, that while pure water lost 60 per cent. of its volume, a recent brine, marking 65° of the salometer, (analysis I) lost but 45 per cent., a fresh pickle 43.66, and an old partly exhausted pickle only 30.05 per cent. of its volume. Were the last to evaporate as rapidly as fresh pickle, it would yield a less quantity of salt, since, as appears from the analysis already given, it contains less salt for the same volume; but in fact, its evaporation is much retarded by the affinity of the earthy chlorids for water. This becomes so manifest that, after a certain stage of concentration, evaporation ceases altogether at ordinary temperatures. It is well known to chemists that these chlorids, if evaporated to dryness by artificial heat, will, on exposure at ordinary temperatures, absorb moisture from the air, and redissolve, or deliquesce, as it is termed. A similar process takes place with the concentrated bitters, which at the temperature of the air lose water in dry weather, and absorb it again in moist weather. This process, and the effect of the purity of the pickle upon the quantity of salt produced, is shewn by the following experiments of Dr. Goessmann:—An artificial pickle, closely resembling the fresh pickle II, and having the composition represented under II A, having been prepared, five glass basins were arranged, and placed in a position exposed to air and light, but sheltered from rain. Of these vessels, 1 was filled with the pickle II A; 2, with equal parts of II A and III; 3, with equal parts of II A and IV; and 4, with equal parts of II A and V; while 5 was supplied only with the impure pickle V. It was found that during the whole season the 600 volumes of this last, taken for the experiment, were never reduced below 320, a bulk which was subsequently augmented to 340 volumes when the damp weather of autumn came on. After an exposure during the whole salt-making season, the salt from each basin was collected and carefully weighed, with the following results, the produce of the fresh pickle being taken at 100:—

Effects of earthy chlorids.

Rates of evaporation.

Goessmann's experiments.

1.	gav. of salt.....	100.00	parts.
2.	" " "	99.72	"
3.	" " "	95.35	"
4.	" " "	81.3	"
5.	" " "	15.60	"

From the sparing solubility of salt in a bittern like V, it results that if fresh pickle be mixed with it, the mixture can no longer hold the whole of the salt in solution, but deposits a considerable portion of it in fine grains. All of these considerations shew that the accumulation of the impure liquors in the salt-covers is to be carefully avoided, and that they should be thrown away before they reach such a stage of concentration and impurity as to retard the efficient working of the process and reduce the yield of salt. Such a result is shewn in the experiments 3 and 4, where the falling off in the production is seen to be five and nineteen per centum.

Dense pickles. These impure pickles have a specific gravity considerably greater than that of pure saturated brines. Thus, according to Dr. Goessmann, the pickle V, which contains less than nine per cent. of salt, marks 32° on Beaumé's scale, which corresponds to a specific gravity of about 1.278, and would equal 123° of the ordinary salometer, were the scale of this instrument to be extended; while a pure saturated brine, of 100° of the salometer, corresponds very nearly to 25° of Beaumé's areometer. Dr. Goessmann recommends this latter instrument to be used for testing the old liquors, and states that a pickle marking 30° Beaumé (equal to a specific gravity of 1.256) is to be rejected, as no longer fit for the purpose of making solar salt.

It will be seen from the analyses already given that the small amounts of chlorid of potassium and bromid of magnesium which these brines contain, accumulate in the old pickle, and might, perhaps, in some cases be turned to account as sources of potash and of bromine. Though this is not attempted at Syracuse, bromine is manufactured from the bitterns of salt-springs in western Pennsylvania and in Germany, and potash salts are extracted from the bittern of sea-water on the shores of the Mediterranean. The brines of Goderich are fortunately so pure that these foreign elements are present in too small amount to be of significance, although traces of both potash and bromine are found in them.

Bromine.

As we have seen that the earthy chlorids are the most objectionable impurities in natural brines, it will be well to compare our own with those of Syracuse and of Saginaw. The following table shews the proportion of the two chlorids united, and also that of the sulphate of lime, calculated for 100.00 (one hundred parts) of the solid matters of the different brines; the difference between the sum of these and 100.00, being in each case pure salt.

Brines compared.

		<i>Earthy chlorids. Su'phate of lime.</i>	
Goderich.	1. Goderich Co's. well, Aug. 1866.....	·26	·69
	2. " " Apr. 1867.....	·22	2·19
	3. " " Nov. 1868.....	25	2·00
	4. Clinton " " "	·31	2·65
	5. Kincardine " " "	·44	1·33

6.	Syracuse brine, analysis I, page 232,.....	1.42	3.51	Syracuse.
7.	" saturated salt pickle,.....	1.81	1.54	
8.	Saginaw brine (analysis by Douglas),.....	16.63	.53	Saginaw.
9.	" " (" Dubois),.....	17.42	2.20	
10.	" " (" Chilton),.....	22.89	.45	
11.	" " (" Webb),.....	8.04	undetermined.	

The amount of sulphate of lime in the Goderich brine in August, 1866, before the well was pumped, was very small, though it has since increased. The smaller proportion contained in the Saginaw brines is due to the large amount of earthy chlorids present, which, as we have said, diminish the solubility of sulphate of lime. The proportion of earthy chlorids in the Goderich brines is seen to be but a small fraction of that contained in those of Syracuse; yet in the manufacture of solar salt these chlorids will slowly accumulate, and so require, though to a less degree, the same precautions as at Syracuse for getting rid of them from time to time. The following recommendations for the improvement of the solar salt at that place, copied from the Report of Dr. Goessmann already noticed, which was published in 1864, are therefore worthy of notice. Alluding to the different stages of the process, as described on page 228, which are carried on in three separate systems of vats, known as settling-rooms or deep-rooms, gypsum-or lime-rooms and salt-rooms, he observes :—

" The successful working of these rooms, as a general rule, is best aided by building them in distinct systems, corresponding with the number of processes intended; the succeeding set of rooms always from four to six inches lower than the preceding ones, and every system with a perfectly even bottom, but a distinctly slanting position towards their termination. Such a construction not only favors a desirable independent management of each system of rooms, but admits of a more successful drawing-off of brine or pickle. * * * * * The degree in which the bottom of every system of vats has to incline, is best regulated by the respective lengths of the strings; the longer the string of vats the less may be the rate of inclination. The latter ought to be such as to enable the workmen to draw from every one of these divisions, whenever required, that portion of the saline solution which has reached the desired point for which it was retained there. The flow itself, on the other hand, ought to be sufficiently slow to prevent the stirring up, and thus the carrying along of sedimentary matter to the succeeding division. The latter purpose can be much aided by a proper distribution of gates for discharging the brine from the upper to the lower section. Several small gates properly located are always preferable to one large one; the additional trouble caused by being compelled to open at every new charge or discharge, several gates instead of one, is more than compensated by the decided advantage gained in being enabled to draw or run off the old pickle uniformly, and thus more effectually.

Plan of solar salt works.

ally, towards the termination of the lower rooms. The changes to which the brine is subjected while still in the first two systems of vats—the settling and the gypsum-rooms—manifest themselves, as we have observed, uniformly throughout the whole mass; and the vats being always filled with a saline solution of the same or similar original composition, and terminating also each time with a certain uniform state of the solution, in the form of a saturated pickle, do not exactly require separate divisions within their systems of vats. Nothing remains to be said here in regard to their construction, but that they ought to present a sufficient area of surface for evaporation, to enable the manufacturer to feed his salt-rooms whenever it may be required; this being requisite in order to produce a superior article of salt. It may be a very difficult question to ascertain the exact relative proportion between the surfaces of evaporation in the settling and gypsum rooms on the one hand, and the salt-rooms on the other; yet to find something near to it is one of the most important questions. A satisfactory decision of that question can only be obtained by adopting a method for working the salt-rooms to the best advantage, a method which tends to protect free evaporation in the salt-rooms from retarding influences—influences which are undeniable, yet uncertain in force.”

In relation to the foregoing extract, it is to be observed that the preparatory stage, which requires two sets of rooms at Syracuse, on account of iron in the brine, may, in the absence of this impurity, be effected in a single set of rooms, in which the brine shall be brought to the point of saturation and a portion of gypsum deposited. The stronger the brine also the smaller
 Gypsum-rooms. need be the area of the gypsum-rooms as compared with the salt-rooms, so that the comparative area of the former at Goderich may be very much reduced, as noticed on page 229. The influences alluded to as retarding free evaporation in the salt-rooms are those of the earthy chlorids, which, as already shown in page 231, have—when in considerable quantities—a powerful effect in this way. Hence, the necessity of getting rid of these, from time to time, by drawing off and rejecting the old pickle before it becomes so impure as to become prejudicial. The means of determining this point has already been shown on page 234.

As already remarked above, the settling and gypsum-rooms, in which the evaporation is carried only to the point of saturation, do not require subdivisions in their systems of vats or covers; but for the salt-rooms this is very desirable, and Dr. Goessmann recommends the following arrangement :—
 Salt-rooms. “ The vats are to be built in sub-divisions, with a perfectly even bottom, but slightly inclined towards the termination of the string. The first sub-division, next to the gypsum-rooms, ought to have the largest number of covers, the one following a less number, and the third, if the last, only one cover to every ten or twelve covers preceding in the whole string; for

instance the first division may have twenty covers, the second ten, and the third only three covers. These various divisions ought to be connected with each other by two or, better, three small gates, and the gates between the second and third divisions should be larger than those between the gypsum-rooms and the salt-rooms. These sub-divisions facilitate a proper division and economy of the salt pickle."

The vats or covers used at Syracuse have, as already mentioned, a uniform size of sixteen by eighteen feet, and while settling-vats are generally deeper, those of the gypsum and salt-rooms have a depth of six inches, four inches of which is filled with brine or pickle. This, in the salt-covers, is replaced, as it evaporates, by fresh supplies of pickle, a process which is repeated as often as the salt itself appears above the level of the pickle, and continued until a sufficient amount of salt has been formed for removal. The gathering of the solar salt usually takes place twice or three times during a season. The natural consequence of this system of working is that in proportion as salt is obtained from the pickle the soluble chlorids accumulate in the remaining portion. This accumulation would sooner or later be felt throughout the whole string of vats used for salt-making, particularly if they were built on one level, and supplied with new pickle without certain precautions. Such conditions could not but interfere most seriously with the quality and quantity of the salt. Hence, as Dr. Goessmann emphatically says, the whole system of constructing and supplying the salt-vats during the season should be arranged so as keep the new pickle as much as possible separate from that which is old and partially exhausted.

It is with this object in view that he recommends the arrangement of a string of salt-covers in three successive sub-divisions, numbering, respectively, twenty, ten and three. With such a system "the supply of new pickle ought to be managed with the following precautions: First, draw as much of the remaining old pickle as possible from the second into the third division, then from the first into the second, and, finally, open the gates between the gypsum-room and the first salt-room, which is thus supplied with fresh pickle. Aim always at the most successful separation of the remaining old pickle before supplying the new. The last or lowest cover will thus, in the course of the season, receive almost all the inferior old pickle left from the previous charges of the string. The pickle thus accumulating there will be more or less highly charged with the chlorids of calcium and magnesium, and a few weeks trial in the next season will soon indicate the point where salt-making profitably ceases." As already remarked, this impure or worthless pickle is much denser than saturated brine, and its value diminishes with the increased specific gravity, so that

Salt-covers,
Syracuse.

Mode of working.

Dr. Goessmann informs us that a brine marking 30° of Baume's areometer is worthless for salt-making purposes.

The site selected for solar salt-works should be on well-drained land, free from stagnant waters; the vats should never rest upon the earth, and should turn their open front towards the prevailing currents of air.

Gypsum.

As regards the sulphate of lime, the only foreign material present in any notable quantity in the brines of the Goderich region, it is to be remarked that it separates with the salt, during the process of solar evaporation, in the hydrated form, as small needle-shaped crystals of gypsum, which fill up, more or less, the cavities in imperfectly developed crystals of salt, adhere to the outside of these, or are mixed, in a loose state, with the bulk of the salt. This latter condition "enables the careful manufacturer to separate a considerable portion of the gypsum by subjecting the salt to a careful washing before harvesting it. An accumulation of a certain excess of sulphate of lime within the salt-vats, towards the close of the season, is almost unavoidable, and it is, for this important reason, very advisable to return the small-sized crystals of solar salt—for instance, the scrapings of the salt-vats—at the end of the salt-making season, to the gypsum-rooms. This precaution will not only secure an additional return of a superior quality of salt, afterwards, but will leave the excess of sulphate of lime where it properly belongs;" the yet unsaturated brine of the gypsum-room dissolving the salt, but leaving the gypsum behind. "To start the solar salt-making anew from time to time—for instance, every spring and fall before closing up the works,—is, on account of many advantages, very advisable."

The average amount of sulphate of lime in the solar salt of Syracuse, as calculated from the analysis of a good recently prepared pickle, need never exceed 1.5 per cent., which amount is considerably less than some of the best and most valued foreign coarse salts contain. The smaller quantity of sulphate of lime actually observed in the solar salt from the first gathering of the season, as well as in the coarser grained portion of the second crop, (from 1.815 to 1.316 per cent.) and the more or less increased proportion of it in the finer portion of the various crops, particularly in the last crop of the season, confirm the above statements. Its uniform distribution throughout the whole of every crop, remains, therefore, the sole object of the manufacturer. Sulphate of lime is generally not considered as interfering with the effects expected from good solar salt, yet being a matter foreign to salt, and apparently not directly promoting its specific action, a reduction of its proportion in salt should be sought, if for no other reason, for that of improving the appearance of the product. The means of effecting this has already been pointed out in the preceding paragraph. The proportion of sulphate of lime to 100 parts of the solid matters of the

Goderich brine is shown by the table on pages 234-35 to be considerably less than in the more dilute brines of Syracuse; but the former, during concentration to the condition of a pickle such as is required for solar salt, deposits a considerable portion of the sulphate, so that in the pickle it amounts only to 1.54 per cent.; while the Goderich brine, brought to the same condition, holds, on account of its greater purity from the noxious earthy chlorids, an amount of sulphate equal to about 2.0 per cent., or nearly as much as a pure saturated solution of salt. From this it will be seen that, while free, to a remarkable extent, from the chlorids of calcium and magnesium, whose presence is so prejudicial, the Goderich brines contain of the sulphate of lime a somewhat larger proportion than the Onondaga salt. This compound, as already remarked, is however no way injurious to the quality of the salt; in fact, the best Ashton and Turk's Island salt contain rather more sulphate of lime than that of Syracuse. It is, as already remarked, the earthy chlorids which not only injure the grain of the salt, render it liable to get moist in a damp atmosphere, but prove injurious to the flavor of butter, to which they impart a bitter taste. The presence of these in the ordinary salt of Syracuse having been recognized as impairing its value for the uses of the dairy, the treatment of the boiled, and in some cases of the solar salt by a small portion of carbonate soda, as described on page 227, has been resorted to, producing what is known by the trade-mark of *factory-filled salt*, and, being entirely free from the earthy chlorids, is peculiarly fit for the salting of butter. It is said that while for any other purposes than for the preservation of butter the presence of small quantities of earthy chlorids is of little or no importance, a very small proportion of them suffices to impair the delicate flavor of butter. As our brines contain on an average only one-fifth or one-sixth as much of these objectionable compounds as those of Syracuse, it follows that with the same care in making the salt, either by boiling or by solar evaporation, a salt would be obtained a holding much less proportion of these chlorids than the ordinary salt of Syracuse, and scarcely requiring the subsequent chemical process which is there applied for their removal.

ADVANTAGES OF THE GODERICH REGION FOR SALT-MAKING.

The finding of salt at Goderich attracted, early in 1867, the attention of the Onondaga Company, and Dr. Goessmann, who was sent to examine and report upon the new discovery, visited the region for that purpose in June, and again in December 1867; his object being to verify the truth of the statement made in my Report, published in the spring of 1867, that the brine of Goderich was the strongest and the purest known, and also to determine what were the facilities offered by that region for the manufacture of salt. In his Report thereon, addressed to the Onondaga Company,

GEOLOGICAL SURVEY OF CANADA.

dated January 1868, Dr. Goessmann thus sums up the result of his examination as to these two points:—

The present brine of Goderich is not only one of the most concentrated and, but also one of the purest, if not the purest, at present turned to the manufacture of salt." After referring to the discovery of salt at Clinton, Dr. Goessmann proceeds: "Goderich possesses, in a high degree, all necessary natural resources and facilities for the manufacture of salt and its transportation to all the important commercial points in the western lakes, and therefore, the most formidable competitor which the salt-works of the State of New York have ever yet had to contend with." In confirmation of the statements made by me in preceding pages, I make the following citations from the Report in question, premising that they carry the greatest weight, from the known scientific accuracy of Dr. Goessmann, and the fact that he has, as chemist to the Onondaga Company, devoted himself for years to the study of the salt-manufacture:—

It has been shown by the analyses on page 221 that on pumping the Goderich Company's well the density of the brine fell from 100° to 95°, and the amount of sulphate of lime increased. These changes were readily apparent when, in April, 1867, Dr. Goessmann received samples of the brine and of the boiled salt for examination. His analysis of the brine has already been given on page 221, II. He proceeds to remark: "The two samples of brine tested by Dr. Hunt and myself differ in strength by about 1.75 per cent. of salt. The difference in regard to the percentage of gypsum, which effects but little the relative commercial value, may find a satisfactory explanation, etc. * * * The proportion of gypsum obtained by myself is still somewhat less than that contained in the Onondaga brines. Comparing the results of both analyses in regard to the percentage of chlorid of sodium contained in the Goderich brine with that known to be in the average of the brines of Onondaga, (about 16 per cent.) we notice that the Goderich brine in either case exceeds the average by about 50 per cent. of salt, or more; while the proportion of noxious deliquescent chlorids contained in the Goderich brine amounts only one-fourth or one-fifth of that found in the brines of Onondaga."

A sample of boiled salt from the Goderich works gave as follows:—

Chlorid of sodium.....	97.0309
Chlorid of calcium.....	.0072
Chlorid of magnesium.....	.0313
Sulphate of lime.....	1.4306
Moisture.....	1.5000
	<hr/>
	100.0000

This sample of salt, in a dried state, would contain not less than 98.5 per cent. of chlorid of sodium or pure salt. It ranks, consequently foremost

among the common fine salt (boiled) in the market. In the percentage of the deliquescent chlorids of calcium and magnesium, which are considered the most obnoxious component parts of brine or salt, it compares most favorably with the best foreign and domestic salt. In fact the composition of the Goderich brine is such as to warrant, *à priori*, with but little care, a superior salt, common, fine and coarse. The commercial value of the brine of Goderich, in consequence of its superior purity as compared with the brine of Onondaga, is, judging from the previous statements, quite obvious. The Michigan (Saginaw) and Ohio River brines, I need scarcely add, have still less chance to compete on anything like equal terms."

"The salt," he adds, further on, "is, after separation from the pickle, as might have been expected from a brine like the Goderich, of a superior color, and of a hard and fine grain, resembling the best brands of home and foreign manufacture, and this result is attained without any but the ordinary care required for the manufacture of common fine salt. It will be noticed that the sole objection which may be urged against the Goderich brine is merely incidental, for the brine is too strong to be worked to its full advantage by the system of manufacture at present pursued."

The low price at which English salt is imported makes it probable that the product of the Goderich region can scarcely compete with it in that part of the Dominion to the east of Lake Ontario, while the wells already sunk are probably more than sufficient to supply the remaining portion of the country. From these considerations it would seem that the only chance for a further development of the salt resources of the Goderich region is be found in the United States market. The present duty on salt entering that country amounts, however, to twenty-four cents in gold on 100 pounds of packed salt, and eighteen cents on 100 pounds of loose salt, making it, upon the barrel of 280 pounds, \$0.67². By a proper system of evaporation, either by solar heat, or by a more economical use of fuel, as has been already pointed out, Dr. Goessmann conceives that the net cost of the barrel of fine salt, the barrel included (which costs 30c.), should not exceed \$0.70, while the freight from Goderich to Chicago would cost 10c.; to this he adds for storage, landing, selling, etc., at Chicago, \$0.21 $\frac{1}{2}$, making the cost of a barrel of fine salt from Goderich, delivered at Chicago, \$1.68 $\frac{1}{2}$. This, at the price ruling in January, 1868, would leave a small margin for profit, which might be increased if the salt were shipped loose, and thus entered at a reduced duty. For this traffic the position of Goderich, on the lake, and at the terminus of a railway, offers very great advantages; and, but for the duty against which it has to contend, it seems probable that the salt region of Goderich, stretching, apparently, to Clinton on the one side and to Kincardine on the other, might, from the greater purity and strength of its brines, command the market of the north-western United States.

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Table giving a comparison of different expressions

Feet; meter.	Degrees; Baumé.	Specific gravity.	Per cent. of Salt.	Grains of Salt in one pint.	Gallons for a barrel of Salt.
0	0	1.000	0	0	Infinite.
1	.26	1.002	0.26	19	2599
2	.52	1.003	0.51	38	1297
3	.78	1.005	0.77	56	863
4	1.04	1.007	1.03	75	647
5	1.30	1.009	1.28	94	516
6	1.56	1.010	1.54	114	430
7	1.82	1.012	1.80	133	368
8	2.08	1.014	2.06	152	321
9	2.34	1.016	2.31	171	285
10	2.60	1.017	2.57	191	256
11	2.86	1.019	2.83	210	232
12	3.12	1.021	3.08	229	213
13	3.38	1.023	3.34	249	196
14	3.64	1.025	3.60	269	182
15	3.90	1.026	3.85	288	169
16	4.16	1.028	4.11	308	158
17	4.42	1.030	4.37	328	149
18	4.68	1.032	4.63	348	140
19	4.94	1.034	4.88	368	133
20	5.20	1.036	5.14	388	126
21	5.46	1.037	5.40	408	120
22	5.72	1.039	5.65	428	114
23	5.98	1.041	5.91	448	109
24	6.24	1.043	6.17	469	104
25	6.50	1.045	6.42	489	99.7
26	6.76	1.046	6.68	510	95.7
27	7.02	1.048	6.94	530	92.0
28	7.28	1.050	7.20	551	89.5
29	7.54	1.052	7.45	572	85.3
30	7.80	1.054	7.71	592	82.3
31	8.06	1.056	7.97	613	79.5
32	8.32	1.058	8.22	634	76.9
33	8.58	1.059	8.48	655	74.5
34	8.84	1.061	8.74	676	72.1
35	9.10	1.063	8.99	697	69.9
36	9.36	1.065	9.25	719	67.9
37	9.62	1.067	9.51	740	65.9
38	9.88	1.069	9.77	761	64.1
39	10.14	1.071	10.02	783	62.3
40	10.40	1.073	10.28	804	60.6
41	10.66	1.075	10.54	826	59.1
42	10.92	1.077	10.79	848	57.6
43	11.18	1.079	11.05	869	56.1
44	11.44	1.081	11.31	891	54.7
45	11.70	1.083	11.56	913	53.4
46	11.96	1.085	11.82	935	52.2
47	12.22	1.087	11.08	957	50.9
48	12.48	1.089	12.34	979	49.8
49	12.74	1.091	12.59	1002	48.7
50	13.00	1.093	12.85	1024	47.6

for the strength of Brine from zero to saturation.

Degrees; Salometer.	Degrees; Baumé.	Specific gravity.	Per cent. of Salt.	Grains of Salt in one pint.	Gallons for a bushel of Salt.
51	13.26	1.095	13.11	1047	46.6
52	13.52	1.097	13.36	1070	45.6
53	13.78	1.100	13.62	1092	44.7
54	14.04	1.102	13.88	1115	43.8
55	14.30	1.104	14.13	1137	42.9
56	14.56	1.106	14.39	1160	42.0
57	14.82	1.108	14.65	1183	41.2
58	15.08	1.110	14.91	1206	40.4
59	15.34	1.112	15.16	1229	39.7
60	15.60	1.114	15.42	1252	38.9
61	15.86	1.116	15.68	1276	38.2
62	16.12	1.118	15.93	1299	37.5
63	16.38	1.121	16.19	1322	36.9
64	16.64	1.123	16.45	1346	36.2
65	16.90	1.125	16.70	1370	35.6
66	17.16	1.127	16.96	1393	35.0
67	17.42	1.129	17.22	1417	34.4
68	17.68	1.131	17.48	1441	33.9
69	17.94	1.133	17.73	1465	33.3
70	18.20	1.136	17.99	1489	32.7
71	18.46	1.138	18.25	1513	32.2
72	18.72	1.140	18.50	1538	31.7
73	18.98	1.142	18.76	1562	31.2
74	19.24	1.144	19.02	1587	30.7
75	19.50	1.147	19.27	1611	30.3
76	19.76	1.149	19.53	1636	29.8
77	20.02	1.151	19.79	1661	29.4
78	20.28	1.154	20.05	1686	28.9
79	20.54	1.156	20.30	1710	28.5
80	20.80	1.158	20.56	1736	28.1
81	21.06	1.160	20.82	1761	27.7
82	21.32	1.163	21.07	1786	27.3
83	21.58	1.165	21.33	1811	26.9
84	21.84	1.167	21.59	1837	26.5
85	22.10	1.170	21.84	1862	26.2
86	22.36	1.172	22.10	1888	25.8
87	22.62	1.175	22.36	1914	25.5
88	22.88	1.177	22.62	1940	25.1
89	23.14	1.179	22.87	1966	24.8
90	23.40	1.182	23.13	1992	24.5
91	23.66	1.184	23.39	2018	24.2
92	23.92	1.186	23.64	2045	23.8
93	24.18	1.189	23.90	2072	23.5
94	24.44	1.191	24.16	2098	23.2
95	24.70	1.194	24.41	2124	23.0
96	24.96	1.196	24.67	2151	22.7
97	25.22	1.198	24.93	2178	22.4
98	25.48	1.201	25.19	2205	22.1
99	25.74	1.203	25.44	2232	21.8
100	26.00	1.205	25.70	2259	21.6
...

GEOLOGICAL SURVEY OF CANADA.

The preceding table is extracted from Professor Alexander Winchell's report on the geology of Michigan, published in 1861. An abstract of it is given in my Report for 1866, but it has been thought advisable to give it at length as a guide to our salt-manufacturers. Pure water contains at ordinary temperature a little over one-third its weight of salt, or thirty-five to thirty-six hundredths. The amount varies somewhat with the temperature, and the results of different experiments are more or less perfectly accordant, but from the most accurate observations it results that 100 parts by weight of pure saturated brine, at temperatures 32° to 70° F., contain from 26.8 to 26.7 parts of salt. Some determinations however, gave but 25.7 parts, and upon this figure the following table was calculated.

The specific gravity of a saturated brine at 60° F. is 1.205, pure water being 1.000. The salometer employed in many salt-works for the value of brines is an areometer with an arbitrary scale divided into 100 parts. The density of pure water on this scale is represented by 100°, and that of saturated brine by 120.5°; each degree of the salometer, therefore, corresponds very nearly to one-quarter of one per cent of salt. The areometer or hydrometer of Baumé has also an arbitrary scale, but is an instrument in common use and may conveniently replace the salometer. In the following table the true specific gravity, with the corresponding degrees of the salometer, and of the hydrometer of Baumé are given in the first three columns. The succeeding columns give the percentage of salt in a pure brine for each degree of the salometer, the number of cubic inches of salt to the wine pint of 36.625 cubic inches, and the number of bushels of such brine required to yield a bushel of salt, weighing 56 pounds. The latter numbers are based upon the supposition that a saturated brine contains only 25.7 per cent of salt, but if we take into account the effect of all quantities of earthy chlorids and other impurities which ordinary brines contain, they will be found not only sufficiently accurate for all practical purposes but nearer the truth than if based upon the composition of a purely pure brines.

II. IRON AND IRON ORES.

The iron ores of Canada have been described at considerable length in the *Geology of Canada*, in 1863, and the Report for 1866 contains farther notices of those found in the county of Hastings, with details as to former experiments in working them, on pages 98-103 and 107-113 ; besides notices of localities on the Ottawa, at page 20, and an account of the mode of their occurrence among the Laurentian rocks, which will be found on pages 214-216 of the same Report.

The principal iron ores of Canada are, 1st, the magnetites and hematites of the Laurentian and Huronian systems ; 2nd, similar ores in the Quebec group, in the Eastern Townships of the province of Quebec ; 3rd, the bog ores or limonites of recent origin ; and 4th, the iron sands, to which attention has recently been called. In the above enumeration the provinces of Quebec and Ontario are alone included ; the iron-deposits of the provinces of Nova Scotia and New Brunswick will be made the subject of future study. It is proposed in the present report to call attention to some facts in the history of the first and the last of these four classes, and to give the results of some analyses of these ores.

The iron ores of the Laurentian system are, for the greater part, of the magnetic species, and are similar in geological relations and in mineralogical characters to the ores which occur in the same system in northern New York, and in the Highlands of southern New York and New Jersey, where they have long been mined to a great extent. Similar ores, moreover, abound in Norway and Sweden, where they occur in rocks of the same age, and furnish great quantities of very pure iron, which is famous throughout the markets of the world. Having had opportunities at the Exposition at Paris, in 1867, to learn many facts about the iron-industry of these countries, I have thought it would be well to embody some of them in the present report, as likely to prove valuable to the mining interests of the Dominion. A large portion of both Norway and Sweden is occupied by old gneisses of the Laurentian system, which also comprise the greater part of the provinces of Ontario and Quebec. This geological resemblance, with somewhat similar conditions of soil and climate, gives to any facts relating to the mineralogy and metallurgy of those northern regions, a special interest to the people of Canada.

Ores of Norway
and Sweden.

In the year 1865, according to official data, there were extracted in Sweden 492,474 tons of iron ore, employing 5,062 workmen. The mines or openings from which this amount of ore was raised, are stated to be 524 in number, and some of them are evidently worked on a very small scale. The workings are ordinarily by open cuttings upon the beds or masses of ore, which are described as being very generally in a nearly vertical atti-

Working.

tude, and in solid crystalline rock, requiring but little support by timbering. The mineral is mined with powder, although nitro-glycerine has been tried to some extent. The pay of the workmen ranges from thirty to fifty cents per day, and the cost of the ore, when raised, is said to vary from one to two dollars for the ton of 1000 kilogrammes (2205 pounds avoirdupois). With the exception of a small quantity carried into Finland, the whole of this ore is smelted in the country. The production of iron ores in Norway is much less than Sweden; about 22,000 tons are raised annually, of which 2500 tons are exported, the remainder being smelted in blast-furnaces with charcoal. At one of the most important of these, that of Laurvig, where a remarkably fine iron is made for the American market, the cost of the ore at the furnace is stated at \$1.80 the ton.

Charcoal
making.

In Sweden, and in Norway, charcoal is the only fuel employed for the reduction of the iron ores, except in some rare instances, where a mixture of charcoal and dry wood has been used in the blast furnace. Careful trials, however, appear to show that this admixture offers no advantages over the use of charcoal alone. About one-third of the surface of Sweden is covered with forests, which constitute an important source of wealth to the country, and of late years have been the object of care and attention, with a view to a due economy of fuel and lumber. The trees of the Swedish forests, with the exception of the southern peninsula, where oak and beech are met with, are chiefly of coniferous or soft-wooded species, and the pine of the country (*Pinus sylvestris*) is the one principally used for metallurgical purposes, the timber being sawn or hewn for lumber, while the branches are employed for the manufacture of charcoal. The wood is cut in the months of March and April, before the rising of the sap, and is divided into lengths of about eight feet, which are allowed to dry during the summer months. The charcoal-burning takes place in October and November, and is generally carried on in circular piles about twelve feet high and from twenty to thirty feet or more in diameter. The burning of a pile lasts from two to three weeks from the time of kindling. Experience has shown, in Sweden, that the economy is much greater when the wood is laid upon its side in the piles than when placed on end. In the latter case the yield of charcoal is from 60 to 62 per cent. of the volume of the wood, while in the former it is not less than 70 per cent. According to a Report to the Swedish Minister of Agriculture, Commerce and Public Works, published in 1866, the average cost of labor for a pile yielding from twelve to thirteen tons of charcoal, is 84 francs, which is equal to about \$1.30 for the ton of 1000 kilogrammes. This price includes the cutting and drawing of the wood.

The cubic meter or stere of 35.317 cubic feet of pine charcoal in Sweden weighs from 142 to 145 kilogrammes, so that the ton of 1000 kilogrammes

(2205 pounds) would measure very nearly 7 steres, or 247 cubic feet, and the weight of the cubic foot of charcoal would be a little over 4 kilograms, or 8.8 pounds, nearly. According to figures given by Grill, however, (Percy, *Metallurgy of Iron*, page 596) a ton of the charcoal used in the Lancashire hearths, in Sweden, measures not less than 297 cubic feet. In the American iron-regions charcoal is bought and sold by the bushel, which is an arbitrary measure of about five pecks, equal, according to Overman, to 2600 cubic inches, and according to Osborn to 2675 cubic inches, (the United-States standard, or Winchester bushel, measuring 2150.42 cubic inches.) Taking the latter figure, we find that the American charcoal-bushel of Swedish pine-charcoal would weigh a little over 18.5 pounds avoirdupois.

Weights of
charcoal.

The experiments of François, in the Pyrennees, give for the weight of the cubic meter of charcoal of beech and oak, from 218 to 235 kilogrammes, that of alder being 141, and that of pine and spruce from 152 to 173. He deduces as the mean for hard-wood charcoal 227, and for soft-wood, 170 kilogrammes, corresponding respectively to 21.9 and 16.4 pounds avoirdupois for the charcoal-bushel as above. (Jules François, *Des Minerais de Fer*, etc., page 177.) The elaborate studies of Mr. Marcus Bull on the charcoal from North American woods, give the following as the weights, in pounds, of a bushel of dry charcoal from these kinds, among others: red cedar 12.52, white pine 15.42, yellow pine 17.52, white birch 19.15, and several varieties of maple and oak from 21 to 23 pounds.* This last is confirmed by the observation of Mr. Kennedy, at the Hull Iron-works, who informed me that a bushel of mixed beech and maple, such as there used, weighed from 22 to 23 pounds.

The cubic meter is equal to about 22.8 charcoal-bushels of 2675 cubic inches, and the price of the cubic meter of charcoal, which reaches at some furnaces, \$1.30, is on an average, in Sweden, 85 cents, or about four cents the bushel. At the iron furnace of Laurvig, in Norway, the cost of good charcoal is said to from 60 to 70 cents the cubic meter.

Cost of coal.

In a few localities in Sweden, where water-courses afford facilities for floating the wood to the furnaces, the charring is effected in ovens of a peculiar construction, furnished with an arrangement for condensing the acid and tarry products given off during the process. The plan of one of these furnaces, shown at Paris, in 1867, was similar to that figured by Dr. Percy, on page 125 of his first volume on *Metallurgy*, in which will be found discussed in great detail, the whole subject of charcoal-burning, on pages 107-142.

* These results were published in the Transactions of the American Philos. Society, for 1826, new series, pp. 1-60, and are reproduced in the American edition of Knapps Technology, i, 24.

cannon, according to Rinman, a very strong metal is obtained by adding to the charge a small amount of sulphuret of iron, and in general for this purpose a charge is preferred free from phosphorus, but somewhat sulphurous. The sulphur causes a larger proportion of carbon to remain in a combined state; a very tenacious mottled cast iron is obtained, holding about 0.09 per cent of sulphur, and the quantity may even rise to 0.30 or 0.50 per cent. The use of sulphurous ores, according to Rinman, like that of manganesian ores, enables us to obtain white iron when the furnace is running at its ordinary rate, and without any overcharge of ore.

Phosphorus.

Phosphorus, in like manner, though it renders wrought iron cold-short, gives to it a hardness which renders it peculiarly valuable for some purposes, as for boiler-plates, roofing-sheets, spades, shovels and hoes, and other utensils which are exposed to severe wear. In the metal for these, at least 0.1 per cent of phosphorus, and in that for fine castings as much as 0.5 per cent, is considered advantageous, as contributing in the latter case to give greater fusibility and fluidity to the melted metal. But for the manufacture of steel, phosphorus seems to exert a highly prejudicial influence, and it appears from carefully-made analyses of Swedish irons, that their value in the Sheffield market, where their relative fitness for the manufacture of steel has been determined by experience, is, as shewn by Rinman, directly in proportion to their freedom from phosphorus.

The amount of phosphorus in the ores of Dannemora, Bispberg, and some other of the Swedish mines does not exceed 0.005 per cent., while in some others, as Gellivara and Graengesberg, it rises to 1.3 and even 2.0 per cent. Some of these ores, like similar ores in northern New York, contain imbedded grains of phosphate of lime or apatite. It is, however, to be remarked that the whole of the phosphorus in the charge does not pass into the ores, and moreover, that the proportion of this element varies in different parts of the deposit, so that by a judicious admixture of the phosphuretted with purer ores, the resulting cast iron will not contain more than 0.15 per cent. of phosphorus, which does not render it unfit for ordinary uses.

Manganese.

Manganese is also conceived to exert an important influence, in more ways than one, upon the quality of iron. The Swedish ores not unfrequently contain a portion of this element, and when absent from any ore it is sought to be supplied by mixtures containing manganese. While the greater part of it passes into the slags, a certain portion remains in the cast iron, and to its presence it is customary to ascribe a peculiar fitness in the resulting malleable iron for the manufacture of steel. It is, however, remarked that manganese is often wanting, without any observed inferiority in the cast iron.

The presence of titanium, and its influence upon iron, is a subject which has

of late been very much debated. While claimed by Mr. Mushet, and some others, to exert a special and most beneficial influence on the quality of steel, this is denied by others. When ores containing titanium are smelted, Titanium. a small portion of this element, amounting in some cases to a little over one per cent., passes into the cast metal, and is said to increase its strength, besides giving it a peculiar mottled aspect. It seems, however, "doubtful whether any titanium remains in the bar iron or steel made from such pig iron, so that the improvement attributed to the use of titaniferous ore is probably due to some indirect action, rather than to the actual presence of titanium in the finished product. The evidence on this point is not sufficiently clear to allow of any positive conclusion being formed." To the above statement of Bauerman, I may add that I have failed to detect any titanium in bloom iron made by the direct method from an iron ore containing 16 per cent. of titanium, which will be described further on.

Some remarks upon the composition and the results of analyses of the Swedish ores may not be without value, as serving for comparison with the iron ores of Canada. The iron, both of Sweden and of Norway, is made, with but few exceptions, from ores of the magnetic species. That of the famous Dannemora district, which supplies a great number of blast-furnaces, and produces an iron regarded as superior to all others for the manufacture of steel, occurs as an irregular interrupted belt, a mile and a half in length, which is imbedded in crystalline limestone, with a kind of petrosilicious rock, and has been mined to a depth of more than 100 fathoms. The composition of different portions of the deposit presents considerable variation. Average specimens from one of the most important masses, sent to the Paris Exhibition in a roasted state, as prepared for the furnace, showed considerable admixtures of silica, lime and magnesia, with some alumina. Dannemora ore. The sum of the united protoxyd and peroxyd of iron for these two ores, was respectively about 54 and 68 per cent., equalling 38.5 and 48.6 per cent of metallic iron. These two ores were almost destitute of sulphur and phosphorus, and had the advantage, when mixed, of yielding a fusible slag without the addition of any limestone for flux. Others of the Swedish ores are much richer in iron than these, while others, still, are very much poorer. Thus, at Taberg, an ore is mined, which Taberg ore. consists of magnetic iron disseminated through a serpentine, (sometimes described as a diorite), the magnetic oxyd constituting not more than one half of the mass. This ore, which contains at the same time, from 6 to 10 per cent. of titanac acid, yields only about 25 or 30 per cent of iron. It is melted with about one-fourth its weight of limestone as a flux, and gives a white mirror-like cast metal, which yields an iron much esteemed for wire-drawing. Fuel being cheap in the neighborhood, this ore is extensively mined and smelted. Bauerman states that attempts were made to

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re, previously dressed so as to yield 43 per cent of iron, but for e it was necessary to bring it to such a finely divided condition, judged better to smelt it in its natural state, the expense due ased consumption of fuel, being counter-balanced by greater faci- tment. Besides this of Taberg, other similar ores have long ed in Norway and in Finland. The ore from the Cristine mine ë, in southern Norway, is described as a brilliant black titanife- tite, not very strongly attracted by the magnet, and intermixed of quartz, and of greenish-black hornblende, with a little magne-

It contained no phosphorus, but gave by analysis 42.0 per tallic iron, besides 15.10 of titanio acid and 19.9 of silica, with ount of earthy bases. Inasmuch as many of our Canadian ore or less titaniferous, the following notes with regard to the is and other titaniferous ores are of much interest. They are rom a communication by Mr. David Forbes, in the *Chemical* December 11, 1868.

perience of the Scandinavian iron-masters has shown that the ion to the use of titaniferous ores is that they are found to be ctory in the blast-furnace, in proportion as they contain percentage of titanio acid; and if much titanium is present e a so much larger amount of charcoal to smelt them as not to r employment profitable in a country where other ores free from in be obtained at a reasonable rate. After considerable expe- melting the ore of Kragerö, which yielded a very good iron, it unprofitable to smelt it alone, for the above reason; but its use beneficial when employed in about equal proportions with the of the district, which were free from titanium." Mr. Forbes as experience, that by employing a mixture of crushed quartz and us a flux, when the proportion of titanium in the ore did not ht per cent, or was reduced to this amount by admixture of rom titanio acid, no difficulty was experienced in working this r and profitably. The iron produced was free from phosphorus, , trace of sulphur, and only 0.05 of titanio acid, which was sup- e mechanically present rather than chemically combined with the ther very similar ore from Eger, which contained 38.89 per ron and 7.10 of titanio acid, was found to contain too much d phosphorus to be fit for bar iron, but yielded a good foundry-pig ch gave by analysis 0.26 of titanio acid. When smelted alone it tory, and did not yield a liquid slag, but it was readily fused when at Kragerö, with ores destitute of titanium.

perience of the iron-masters in New York, who have endeavored ie titaniferous ores of Lake Champlain, generally in admixture

with other ores, has been very unfavorable, but an attention to the above suggestions might probably enable them to overcome the difficulties hitherto encountered. Besides the great bed of ore at Bay St. Paul, holding nearly half its weight of titanic acid, Canada has large deposits of ores containing more or less titanium, some of which will be described farther on. In the *Geology of Canada*, page 501, I have shown that a massive granular titaniferous ore from St. François, on the Chaudière, in the province of Quebec, consists of a mixture of about two-thirds of nearly pure magnetic oxyd of iron, and one-third of a titanic iron or menaccanite holding not less than 48 per cent of titanic acid. The two are, however, readily separable by a magnet, and it is probable that by a magnetic separating machine it will be possible to make use of this and of similar ores for the preparation of iron in the direct way, to which the purified magnetic oxyd is well adapted. The iron sands, which contain a large admixture of titanic iron, will be noticed in their place.

Titanic ores.

In this connection I quote from Osborn's recently published volume on the *Metallurgy of Iron and Steel*, page 475, the following statements, which he gives as a communication from a Mr. Henderson, according to whom an ore from Norway, holding over 40 per cent of titanic acid, is now successfully smelted at Norton, in England, by a process patented by Player of New York. The ore is said to be smelted in small furnaces, with a blast at 1000° temperature; 2 tons of coal being required to 2½ tons of the ore, with 15 cwt. of limestone, and about 10 cwt. of basalt. The pig-metal thus produced is stated to contain very little carbon, and to be very easily puddled, producing a malleable iron of great tensile strength. Such ores are necessarily poor in iron, as compared with magnetic ores, and even if they can be readily smelted by the above treatment, it remains to be seen whether their use offers any real advantage.

ANALYSES OF SOME IRON ORES.

The bed of magnetic ore, which has long been known at Hull, is described in the *Geology of Canada*, page 674. The association of a portion of a red hematite with the magnetic ore, and of graphite with both, is described in the Report of the Survey for 1866, p. 216. Since then a large blast-furnace has been erected here, which for some time produced a superior quality of pig-iron; but the working has been since abandoned, the economic results not being satisfactory. The two samples whose analyses are here given had been prepared for that purpose by Mr. Kennedy, the director of the works, and selected so as to represent the average of the ore smelted. One of these, designated at the furnace as the red ore, was colored by an admixture of hematite, while the other was known as the black ore. The red ore gave as follows:—

Hull, Ontario.

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Peroxyd of iron.....	66.20	} = metallic iron 58.79.
Protoxyd of iron.....	17.78	
Oxyd of manganese.....	traces.	
Lime, as silicate.....	.76	
Magnesia, as silicate.....	.45	
Carbonate of lime.....	2.66	
Silica	10.44	
Graphite.....	.71	
Phosphorus.....	.015	
Salpêtr.....	.280	
	<hr/>	
	99.296	

black magnetic ore of Hull contains a considerable amount of silica, or with a portion of a hydrated silicate of iron and magnesia, which the ore to yield an olive-brown powder. When the magnetic is removed from the pulverized ore by a magnet, there remains a considerable proportion of dull olive-colored earthy matter, which gives a brown streak, and is readily attached by hydrochloric acid, with separation of flocculent silica. In the following analysis of an average sample ore the whole was treated together, and all of the iron is represented by magnetic oxyd. Neither of the ores from Hull yielded any titanate acid, the black ore contained neither lime nor manganese. It gave

Magnetic oxyd of iron.....	73.90 = metallic iron 53.20.
Magnesia.....	1.88
Alumina.....	.61
Silica	20.27
Water.....	3.27
Phosphorus .....	.027
Sulphur .....	.085
	<hr/>
	100.042

height of the Hull blast furnace is 38 feet, its diameter at the top being 10 $\frac{1}{2}$ feet, and at the throat 4 $\frac{1}{2}$ feet; the tuyers are six in number. The charge at the time of my visit, in August 1868, consisted of 100 bushels of hard-wood charcoal, 450 pounds of the above ores, previously reduced, and mixed in equal proportions, and 110 pounds of flux consisting of 65 pounds of crystalline limestone, 27 pounds of clay, and silicious sand 18 pounds. The furnace was then yielding gray pig-iron, at the rate of 56 per cent for the weight of the charge. The consumption of charcoal for the ton of metal, was 170 bushels. The fuel was made from beech and maple, and as I was informed by Mr. J. H. Aldry, weighed from 22 to 23 pounds to the bushel, being at the rate of 35 cwt. of charcoal to the ton of iron.

The furnace was for a time in blast in 1867, and for a longer period,

in 1868. By the kindness of Mr. Phillip S. Ross, the secretary to the Canada Iron-Mining and Manufacturing Company, I have been furnished with a statement of the working results during that season.

The furnace was in blast from April 27 to October 5, 1868, or 163 days, during which time there were consumed as follows:—

Working at
Hull.

Hull ore.....	1835½ tons.	} 1896 tons.
Arnprior (McNab) ore.....	60½ tons.	
Scrap iron.....		7½ "
Limestone (clay and sand not estimated).....		211 "
Charcoal, soft wood at 4½c.....	133.573 bushels.	} 242,782 bushels.
" hard wood at 8c.	95.947 "	
" mixed wood at 5½c.....	13.263 "	
Wood at \$1.25.....		25½ cords.
Peat, 80 tons, yielding of coke.....		21½ tons.
Pig iron produced.....		1,040½ "

The cost of the iron thus produced was as follows, per ton:—

For ore, fuel, and wages of men.....	\$22.60
Salaries and general expenses.....	3.10
Cost of a ton of pig iron at Hull.....	<u>\$26.50</u>

If we deduct from the total amount of metal produced, the scrap iron added, we obtain, as the average results during the season of 1868, the following figures:—

Daily production of pig iron.....	6½ tons.
Yield of ore per ton.....	54.5 per cent.
Charcoal consumed per ton of iron (at 5½c cents.).....	235 bushels.
Peat-coke " " "	47 pounds.

If we leave entirely out of the account the amount of peat-coke, and take the average weight of the charcoal at 18 pounds to the bushel, we shall have a consumption of 37½ cwt. of charcoal to the ton of iron, while, with hard-wood charcoal, there were consumed, as above, from 34 to 35 cwt. In Sweden, according to Bauerman, the average consumption of charcoal, for the whole country, is from 16 to 17 cwt., for the ton of white or mottled pig iron, and about one-third more, or from 21 to 22 cwt., for the ton of gray metal suitable for foundry purposes or for Bessemer steel. At Langshytta, the consumption is as low as 13½ to 14 cwt., for the production of white or mottled iron, while the very poor ores of Taberg, already referred to (page 251), where the charge contains only 20 per cent of iron, require as much as 50 or 60 cwt. of charcoal per ton.

**American
furnaces.**

At the Greenwood furnace, near Marquette, on Lake Superior, is a charcoal furnace in which the unroasted ores of the region are smelted with a little crystalline limestone for flux, and yield 55 per cent of iron. To produce a ton of gray pig iron are consumed 140 bushels of charcoal, chiefly of maple, weighing from 16 to 20 pounds each, or about 23 cwt. of charcoal. At the Wyandotte works, near Detroit, where the red slaty hematite of Lake Superior is smelted, and yields on an average 65 per cent of iron, there are consumed 140 bushels of soft-wood charcoal, weighing 14 pounds to the bushel, or $17\frac{1}{2}$ cwt. to the ton of iron. (Bauerman, *Metallurgy of Iron*, p. 206). The recent returns from American blast-furnaces, published by Prof. Egleston, of the School of Mines, New-York, show that while many American charcoal-furnaces are still working in a very wasteful manner, the consumption of charcoal in some in New York and Michigan, is as low as 100 and 105 bushels. At the large blast-furnaces of Port Henry, on Lake Champlain, where magnetic ores similar to that of Hull are smelted with anthracite coal, the average consumption is from 1.10 to 1.14 tons, equal to 22 or 23 cwt. of anthracite to the ton of pig iron.

With these facts before us, it is clear that the rich ores of Hull, with proper management, should be smelted with 22 or 23 cwt. of charcoal, instead of from 35 to 38 cwt., the quantity actually consumed. This alone is sufficient to explain the failure to produce iron profitably at Hull, where the supply of rich ore is abundant, and the quality of the iron made was excellent.

Hull iron.

It is evident from the analyses of the ores above given that the addition of sand and clay to the charge was unnecessary, and that limestone alone, in proper proportion, would have been sufficient for the purposes of a flux. A series of samples of pig iron made at the Hull furnace, was taken by me for analysis, but the results not being yet complete, are reserved for a future report. It may be stated however that a sample of the white iron made with a mixture of peat-coke and charcoal, contained 0.085 of phosphorus and 0.28 of sulphur. This amount of sulphur may be due to the considerable proportion which, in the form of sulphate of lime, I have found in the ashes of some Canadian peats.

St. Maurice.—In the well known blast-furnaces of Messrs. McDougall at St. Maurice, near Three Rivers, in the province of Quebec, where the bog ores of the region are smelted with a hot blast, the charge consists of 500 pounds of ore, with 25 pounds of limestone, and 16 bushels of mixed charcoal. The results for the month of December, 1868, showed a consumption of 26,272 bushels of charcoal and 372 tons of ore, with a yield of $163\frac{1}{4}$ tons of iron, of which about eleven-twelfths were soft grey pig. This gives a production, for the ore, of 43 per cent of iron, with a

consumption of 161 bushels of charcoal to the ton. The results of several analyses of the ores of this vicinity, made by me in 1852, are given in the *Geology of Canada*, page 511, and show them to contain more or less manganese, and a considerable proportion of phosphates. The analysis of a specimen of grey pig iron made at St. Maurice, in 1868, gave me the following results for 100 parts.

Iron.....	not determined
Graphite.....	2.830
Carbon, combined.....	1.100
Sulphur.....	.025
Phosphorus.....	.450
Silicon..	.860
Manganese	1.240

The average produce of the St. Maurice forges is about eight tons of iron daily, which is employed for foundry purposes, and is much esteemed for railway wheels. Some four years ago, a small quantity of wrought iron was manufactured from it, in a hearth-refinery, but the quality of the product was somewhat irregular, and the manufacture was abandoned. It is proposed, in a subsequent report, to give the results of farther studies of these and other irons.

South Crosby. A large deposit of magnetic iron ore is found on an island in Mud Lake, on the Rideau Canal, in the township of South Crosby, and not far from Newborough. (See *Geology of Canada*, page 671.) Considerable quantities of this ore have been mined, and shipped to Pittsburg, and to Chicago, for use in puddling-furnaces. This ore, however contains, besides an admixture of chloritic matter, a considerable proportion of titanium, and more or less sulphur in the form of disseminated grains of pyrites. The specimen selected for examination was from a large block sent to the Museum of the Survey, by the Messrs. Chaffey, some years since. Its analysis showed the presence of considerable amounts of alumina, magnesia and water, which belong to the intermingled chloritic mineral. The iron is calculated as magnetic oxyd, although a portion, uncertain in amount, doubtless exists as protoxyd, in combination with the titanous acid, and with silica, besides that which enters into the composition of the sulphuret of iron present. An average sample yielded as follows ;

Magnetic oxyd of iron.....	69.77 = metallic iron 50.23.
Titanous acid.....	9.80
Magnesia	4.50
Alumina	5.65
Silica	7.10
Water	2.45
Phosphorus.....	.085
Sulphur	1.520 = pyrites 2.85.
	<hr/>
	100.875

GEOLOGICAL SURVEY OF CANADA.

analysis of another portion of this ore, by Dr. A. A. Hayes of Boston, 1.49 of sulphur, 5.04 of silica, 4.42 of magnesia, and 16.45 of titanic

When the pulverized ore is treated with a magnet, it is partially ad, the non-magnetic portion retaining the sulphur, and a large part titanium. The magnetic portion equalled 74.2 per cent, and contained 54.76 per cent of metallic iron and 5.70 of titanic acid.

with Crosby. A specimen of iron ore examined from what is said to be a large deposit on the land of Hon. George W. Allan of Toronto, is bright crystalline magnetite, free from any visible trace of pyrites, and containing but a small amount of sulphur. Its analysis gave

Magnetic oxyd of iron.....	90.14 = metallic iron 64.90
Titanic acid.....	1.03
Oxyd of manganese.....	traces.
Alumina.....	1.33
Lime.....	.82
Magnesia.....	.84
Insoluble.....	5.25
Phosphorus.....	.007
Sulphur.....	.120
	<hr/>
	99.537

The protoxyd and peroxyd of iron in this ore were separately determined, and found to be exactly in the proportions required by theory for the magnetic oxyd. The insoluble residue was chiefly white quartz, with a black mica and green pyroxene; it was found in another specimen to contain 10.80 per cent. This is a very fine and valuable ore, and the results would seem to be worthy of careful examination.

Belmont. The great deposits of iron ore at Belmont have been described in the *Geology of Canada*, page 676 and in the report for 1866, page 100. Since that time, extensive mining operations have there been carried on, and the ore has been shipped to Pittsburg, Pennsylvania. Much of it was found objectionable, on account of the considerable proportion of sulphur which it contained, but an excavation made in the immediate neighbourhood of former workings, and on what is called the Sand-pit bed, has yielded a much purer ore, to which reference is made in Mr. Vennor's Report in volume, page 161. I obtained, by crushing several fragments of the ore taken from a pile at the furnace of Messrs. Shoenberger & Blair, in Pittsburg, Pennsylvania, what seemed an average sample. It was reddish brown, an admixture of hematite, and yielded

Magnetic oxyd of iron.....	72.80 = metallic iron 52.41.
Magnesia.....	6.46
Lime.....	.35

Carbonate of lime.....	2.40
" " magnesia.....	.84
Water	3.50
Insoluble.....	14.73
Phosphorus.....	.035
Sulphur.....	.027
	<hr/>
	101.142

The analysis of another sample of the Sand-pit ore gave of metallic iron 48.99, water 3.65, carbonate of lime 8.03, carbonate of magnesia 0.48, and insoluble residue 16.52. The carbonates were removed, in both analyses, by acetic acid. The ore contains a considerable admixture of a magnesian silicate decomposable by hydrochloric acid, so that the insoluble residue contains a proportion of soluble silica, which, in the second analysis here given, was equal to 4.25 per cent. The remainder was a silicate of magnesia, iron and a little lime, approaching to pyroxene in composition. The determinations given in this paragraph are by my chemical assistant, Mr. Gordon Broome.

Madoc. The Seymour ore-bed in Madoc is described in the *Geology of Madoc. Canada*, page 675, and is further noticed in the Report for 1866, page 98. It was formerly mined and smelted to a small extent, and is a fine grained magnetite, free from pyrites. The analysis gave me

Magnetic oxyd of iron.....	89.22 = metallic iron 64.23.
Insoluble.....	10.43
Phosphorus.....	.012
Sulphur.....	.073
	<hr/>
	99.725

The solution of the ore in hydrochloric acid held neither lime nor manganese. The insoluble residue was decomposed by heating with a mixture of fluorid and sulphate of ammonium, and gave magnesia 17.15, lime 11.01, protoxyd of iron 11.95, silica, by difference, 59.89. This is the composition of actinolite, a mineral which is occasionally found in radiating masses in the midst of the ore.

McNab. The hematite of McNab is described in the *Geology of McNab. Canada*, page 677. It has been mined to some extent, and shipped to the United States, and was also used in a small amount at the Hull iron-furnace in 1868, as already described. It is a purplish-red compact or finely crystalline ore, and holds small quantities of silicious matter and of carbonate of lime irregularly disseminated. An analysis by me made in 1847, and cited in the *Geology of Canada*, gave peroxyd of iron 84.10, carbonate of lime 8.80, silica 4.00. A more complete analysis of another specimen has since given me as follows :

Peroxyd of iron.....	84.42 = metallic iron 59.09.
Carbonate of lime.....	5.40
“ “ magnesia	1.05
Insoluble.....	7.16
Phosphorus.....	.030
Sulphur .....	.065
	<hr/> 99.135

Gros Cap, Lake Superior. The deposit of hematite which occurs at Gros Cap, on the north side of Michipicoten Harbor, has been described by Mr. Macfarlane in the report for 1866, page 130. A specimen of the ore, selected by him, was submitted to analysis, with the following results.

Peroxyd of iron.....	86.80
Insoluble.....	12.75
Phosphorus.....	traces.
Sulphur.....	.092
	<hr/> 99.642

This ore contained no lime, and the insoluble residue, which was white, appeared to be pure silica.

Bay of Seven Islands. On a small stream known as the Rapid River which empties into the Bay of Seven Islands, there occurs, a few hundred yards from its mouth, a great mass of iron ore imbedded in the granite or labradorite rock of the country. The ore, with the exception of an occasional included portion of norite, appeared to occupy the bed and both banks of the stream for a breadth, east and west, estimated at about 100 yards, and is said to extend for some distance north and south, but, owing to a heavy storm at the time of my visit, its limits were not ascertained. The ore is black, brilliant and somewhat coarsely granular. It holds imbedded grains of feldspar, with what appears to be pyroxene, and some iron pyrites. Although pretty strongly magnetic, it contains a large amount of titanium, a partial analysis of an average sample yielding for 100 parts

Protoxyd of iron.....	49.77 = metallic iron 38.50.
Titanic acid	34.30
Insoluble.....	6.35
	<hr/> 90.42

The other bases, derived from the admixture of silicates, were not determined. When pulverized and treated by a magnet it was separated into two portions, one strongly magnetic, equal to 57 per cent. The remainder gave by analysis 51.14 of titanic acid, and 39.75 of peroxyd of iron,

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besides 8.30 of insoluble residue. The magnetic portion, contrary to what might have been expected from the readiness with which it was attracted by the magnet, contained not less than 24.80 per cent of titanitic acid. It was nearly free from silicious impurities, and almost wholly soluble in hydrochloric acid. The existence of a highly magnetic compound, containing so large a proportion of titanium, is interesting, and the substance deserves further study,—meanwhile, as an iron ore, it must take its place with the highly titanitic ores, like that of Bay St. Paul, to which reference has already been made. Should it ever be found advantageous to work such ores, the deposit at the Bay of Seven Islands may be made to furnish a very large quantity.

IRON SANDS.

The silicious sands of most regions contain a greater or less proportion of heavy black grains, which consist chiefly of some ore of iron. The source of these is easily traced to the crystalline rocks which, by their disintegration, have given rise to the sands, and which, in addition to occasional beds or masses of iron ores, generally hold disseminated grains of magnetite, hematite, titanitic iron (menaccanite or ilmenite of mineralogists), and more rarely chromic iron ore. In the process of washing earthy sand for gold, diamonds, or tin ore, considerable quantities of these black iron sands are met with, and, from their high specific gravity, remain while the lighter portions are washed away. The chromic iron ore is comparatively rare, and confined to certain districts; the hematite, with the exception of some crystalline varieties, is generally too soft to resist abrading forces which have reduced the solid rock to sand, so that the black grains, in most districts, consist chiefly of magnetic and titanitic iron ores. In the gold-bearing alluvions of the Chaudière region in Canada the sands obtained in washing for gold, when purified as much as possible by washing, were found to hold eighteen per cent. of magnetic iron. The non-magnetic portion was soluble in acids and fused bisulphate of potash, with the exception of 4.8 per cent. of silicious residue, and the solution contained, besides iron, a considerable proportion of chromium, and 23 per cent. of titanitic acid, derived from the titanitic iron ore, which made up a large portion of the sand. (*Geology of Canada*, page 520.)

The proportion of these ores to the whole mass of ordinary silicious sands is, generally, by no means large, but the action of moving water effects a concentration of the mixture, separating the lighter silicious grains more or less completely from the heavier portions, which consist chiefly of the iron ores, generally with a small quantity of grains of garnet. This separation is effected, on a large scale, by the action of the sea, under

Iron-sand beds. influence of the winds and tides, and the result of this action occasionally gives rise to remarkable accumulations of these heavy iron sands, along the present sea-beaches. A similar process in past ages, during the deposition of the stratified sands, which are now found at heights above the sea-level, has sometimes arranged the iron grains in layers, which are seen to alternate with the lighter silicious sands, as in the deposits of to-day.

Accumulations of these iron sands are met with in many countries. They are found on the shores of Great Britain, along the borders of the Baltic and the Mediterranean, and abundantly on the coast of New Zealand. In some parts of Hindostan and Madagascar the grains of iron ore are extracted by washing from the sands of the country, and employed by the natives in their primitive furnaces, for the manufacture of iron on a small scale. **New Zealand.** The iron sands of New Zealand have of late attracted particular attention from their great extent and richness. According to Hochstetter, the shore of the northern island from Kaipara to Taranaki, a distance of 180 miles, is bordered with a thick layer of iron sand, which contains, according to different analyses, from six to eleven per cent. of titanate of iron.

In North America, black iron sands abound in many places. They occur in great quantities in the lower St. Lawrence, as will be hereafter described, and are met with, in smaller amounts, at various points to the south-westward, along the valley of the St. Lawrence and the great lakes. **Western lakes.** Thus, a deposit of black sand at the outlet of Lake Huron, near Sarnia, attracted some attention, a few years ago; while along the north shore of Lake Erie this sand is, in some places, found in such quantity that attempts were, it is said, made, more than twenty-five years since, to collect it and smelt it with an admixture of bog ore, which was then treated in a blast-furnace, at Normandale, Norfolk county, Ontario.

These black sands are likewise met with at various points along the coast of the United States, particularly on the shores of Connecticut, where they early attracted the attention of the colonists, and were successfully worked more than a century since. **Early workings.** The following details relating to the history of these early and little-known trials, are so interesting that I may be pardoned for introducing them here. It appears by a letter from Mr. Horne, a steel-maker and cutler of London, addressed to Mr. John Ellicot, F.R.S., and read before the Royal Society of London, March 3, 1763, that, at that time, the Society for the Encouragement of Arts and Manufactures was occupied with the question of the Virginian black sand, as it was called. Already, before 1742, one Dr. Moulen, of the Royal Society, had made some unsuccessful experiments to determine the nature of this magnetic sand, but in that year Mr. Horne, having procured a quantity of it, succeeded, as he tells us, in extracting from it more than one-half of its weight of fine malleable iron. He seems, however, to have pub-

lished nothing upon the subject until after Mr. Jared Elliot had made known, twenty years later, by a pamphlet and a letter addressed to the Society of Arts, and subsequently by a letter in reply to Mr. Horne's inquiries, ^{Elliot's trials.} that he was then making malleable iron from the black sands, in blooms of fifty pounds and upwards, by direct treatment in a common bloomary fire, a process which seems, from his letters, to have been one familiar to him. He describes the ore as yielding 60 per cent. of malleable iron, and as being very abundant, and so free from impurity as to require the addition of cinder or of bog ore. This manufacture of iron from the sand had evidently been somewhat developed, for, according to Mr. Elliot, his son had already erected a steel-furnace, before the Act of Parliament was passed prohibiting the manufacture of steel in the colonies. Specimens of the steel there produced were examined by Mr. Horne, and found to be of excellent quality, very tough, and not at all red-short.*

Throughout the essay of Mr. Horne the sand-ore is spoken of as coming from Virginia, a name which in the reign of Elizabeth was given to the whole American coast from Canada to Florida, although in 1643 the name of New England was applied to the region which still bears that name. It appears, however, that the so-called Virginia sand was from the coast of Connecticut. Mr. Elliot's letter to Mr. Henry Horne was dated Killingworth, Oct. 4, 1762. Killingworth is a town in the state of Connecticut, ^{Connecticut.} on the shore of Long Island Sound, twenty-five miles east of New Haven, and was the residence of the Rev. Jared Elliot, D.D., who was not only a divine, but a physician, and a naturalist of great repute. It is recorded of him that "some considerations had led him to believe that the black sand, which appears originally on the beach of the sound, might be wrought into iron. He made an experiment upon it in the year 1761, and succeeded. For this discovery he was honored with a medal by the society instituted in London for the Encouragement of Arts, Manufacturers and Commerce." *

Notwithstanding this successful result, the iron sands seem to have been neglected for the last century, both in America and in Europe. We read, it is true, that such sands are treated in open hearths (bloomaries) at Avellino, near Naples, and within a few years attempts have been made in England to turn to use the iron sands of New Zealand; but the first successful attempts in this country were on the north shore of the lower

* These curious details are extracted from a rare volume entitled *Essays concerning Iron and Steel*, (the first of the three essays being on "The American Sand-Iron,") by Henry Horne, London, 1773. 12mo., pp. 223. A copy of this scarce book is in the possession of W. M. B. Hartley, Esq., of New York.

* Barber's *Historical Collections of Connecticut*, page 531. The Rev. Jared Elliot, who was a grandson of the celebrated John Elliot of Massachusetts, the "Apostle of the Indians," died in 1763, aged seventy-eight years.

St. Lawrence.' The great deposits of black iron sand on the beach near the mouth of the Moisie River, having attracted attention, various attempts to reduce it were made. In January, 1867, Mr. W. M. Molson of Montreal, had the ore successfully treated by the bloomary process, in northern New York, and the result proving satisfactory, several bloomary furnaces were, in 1867, constructed by him at Moisie, and have since been in successful operation.

Molson.

It will here be well to notice the nature and the composition of the iron sand at Moisie, as observed by myself in the summer of 1868. The stratified sands at Moisie, lying about ten feet above high-water mark, penetrated by the roots of small shrubs, and holding marine shells, were observed to be banded by irregular dark colored layers, in which the iron ore predominated. The same thing was afterwards remarked by me in stratified sands at much higher levels in the vicinity. Where these sands form the beach, they are exposed to the action of the waves, which effect a process of concentration, on a grand scale, so that, it is said, after a prevalence of certain winds, great belts of nearly pure black sand are exposed along the shore. At the time of my visit trenches were being sunk to a depth of five feet, on the shelving beach, about half-way between high and low-water mark. The sections presented alternations of nearly pure silicious sand and of black iron sand, the latter in layers of from half an inch to six inches in thickness, often with a small admixture of grains of red garnet, which sometimes formed very thin coatings upon the surface of the black layers. One of these latter, six inches in thickness, was taken up by myself, and found to be very pure, as will be seen from its analysis, farther on. It was easy, from these trenches, by means of shovels, to remove, without much admixture, the thicker layers of the moist black sand, which would measure from one and a-half to two feet out of the five feet excavated. This material was piled upon the beach, and afterwards carried to the washing-table. The supplies of sand-ore have hitherto been obtained from the deposits of wet sand below high-water level. Those at the surface, on the beach, have doubtless been recently moved by the waves, but from the inspection of the layers in the trenches, I was led to the opinion that they were lower strata, similar to those seen above the high-water mark, and, like them, of considerable antiquity. They were found to contain marine shells in a crumbling and decayed condition. It is said that these mixed sands of the higher levels yield, on an average, by washing, about fifteen per cent. of black iron sand. When this poor sand is spread upon the shore, and exposed to the action of the waves and the tide, it is found to become concentrated through the washing-away of the silicious grains. This process helps us to understand the mode in which the irregular layers of rich iron sand have been formed in the

midst of the deposits of silicious sand, in the strata which are now above the sea-level.

The washing of the ore at Moisie, preparatory to smelting, is done upon a shaking-table, about twenty feet long and four feet wide, with a sloping and somewhat concave bottom. Upon this, by the aid of a gentle current of water, a large part of the lighter grains, chiefly of quartz, are washed away. Washing the sand.

The specific gravity of the sand, in bulk, was determined by weighing 100 measured cubic centimeters of it, equivalent to 100 grammes of water; and the proportion of grains of magnetic ore was also determined. Of three specimens from Moisie; A was an average sample of several hundred tons gathered in the manner just described, preparatory to washing; B, a portion taken by myself from a layer six inches thick, about three feet below the surface of the beach; and C, the washed ore, as prepared for the bloomary fire. In this connection are given the results of some similar determinations with iron sands from other localities. Specific gravity.

	<i>Specific gravity.</i>	<i>Magnetic.</i>
Moisie, A.....	2.82	46.3 per cent.
Moisie, B.....	2.88	49.3
Moisie, C.....	2.97	52.0
Mingan	2.84	48.3
Bersimis	2.81	34.3
Natasquan	—	55.7
Kagashka	—	24.0
Batiscan	—	55.0

The specific gravity of the silicious sand with which these iron sands are associated, was found, when determined in bulk, as above, to be about 2.00. It consists chiefly of quartz, whose real specific gravity is about 2.65; that of magnetic iron ore being about 5.18, while the titanite iron ore is about 4.70, and the associated garnet not far from 4.0. The amount of material removed in the process of washing at Moisie is not very great, as may be seen by comparing the proportion of magnetic grains in A and C, the Moisie sand before and after washing. The latter was found by analysis to contain about 5.5 p. c. of insoluble matter, chiefly silicious sand, the remainder being almost entirely oxyd of iron and titanite acid.

The sand of Batiscan, mentioned above, had been purified by washing. Considerable deposits near Champlain, contain, according to Dr. Larue, about 10.0 per cent. of magnetic ore, the remainder being chiefly silicious sand. The specimens from Bersimis, Mingan, Natasquan and Kagashka, however, though collected, as I was informed, without washing, compare favorably with those from Moisie, and, with the exception of Bersimis, even

Bersimis.

surpass it in the proportion of magnetic ore. I am indebted for all of these to Dr. Larue, the professor of chemistry in Laval University, Quebec, who has paid much attention to the iron sands of the lower St. Lawrence, and collected himself the specimen from Bersimis, of which locality he has given me some interesting notes. Besides the considerable accumulations of sand on the beach, he observed, about three feet above high-water mark, two layers of black sand, holding about 30 per cent. of magnetic ore, and separated by a stratum of four inches of a gray sand containing very little iron. The three layers were traced with considerable regularity for 1000 feet along the shore. As we have seen, the sand from the beach at Bersimis contained but 34.3 per cent. of magnetic ore, and had a specific gravity of 2.81; the magnetic portion had, however, a specific gravity of 2.99, and the non-magnetic 2.77. The analyses of both of these will be found farther on.

Bay of Seven Islands.

Mingan.

A deposit of black sand, said to be equal in richness to that of Moisie, is described as stretching along the coast, nearly the whole distance from the Bay of Seven Islands to the mouth of the Moisie River. The sand from Mingan, which is mentioned above, and of which an analysis will be given farther on, is said to be from the west side of the St. John River, at Mingan, but is described as stretching from thence for a distance of three leagues along the coast, and as being very abundant. The deposits of sand at Natasquan and at Kagashka are also stated to be very extensive, and like Mingan, favorably situated for the loading of vessels.

Magnetic separation.

An inspection of the iron sands from the various localities above mentioned, shows that they all contain, besides the ores of iron, a small proportion of red garnet, and more or less of fine silicious sand. The latter of the two substances it is possible to remove almost entirely by careful washing of the crude ore. The use of a magnet enables us to separate the black iron ore grains into a magnetic portion, which is nearly pure magnetic oxyd, and a non-magnetic portion, which is chiefly titanite iron, but, in the specimens submitted to examination, holds a portion of silicious matter, which the imperfectly washed sand still retains. In thus separating the ores into two portions for analysis, the magnetic grains were taken up by a magnet, the poles of which were covered by thin paper, and this process was repeated until the non-magnetic grains were, as far as possible, left behind. The two portions of the ore thus obtained were analyzed separately, the solvent used being, in both cases, hydrochloric acid, which, as is well known, dissolves magnetic oxyd of iron with great facility, and, with certain precautions, may be advantageously employed to dissolve titanite iron ore. For this purpose the non-magnetic portion, having been very finely powdered and sifted, is left to digest with about ten times its weight of hydrochloric acid of specific gravity 1.19, or thereabouts, for

several hours, or until the undissolved residue is no longer black, but grayish or brownish in color. If the process has been conducted with care, and without over-heating, the whole of the iron, and all of the titanic acid which was combined with it, will be found in solution, and may be separated by the ordinary methods. The residue, apparently, contains little else than grains of quartz, with a small proportion of garnet. The finely pulverized ore may also be fused with bisulphate of soda, a process which is more expeditious, and yields equally good results with the last. Chemical analysis.

Moisie.—A specimen of unwashed black sand from Moisie, holding Moisie sand. 49.1 per cent of magnetic grains, was decomposed by digestion with hydrochloric acid, and the residue fused with bisulphate of soda. The titanic acid having been thrown down, by boiling, from the united solutions, the iron was directly determined, the other bases being neglected in this partial analysis, which gave me the following results :—

I.

Protoxyd of iron.....	70.10 = metallic iron 55.23
Titanic acid.....	16.00
Insoluble, chiefly quartz	5.92
	<hr/>
	92.02

A part of the iron in these ores is in a higher state of oxydation than here indicated, but the determination of the degree of oxydation of the iron in titanic ores is difficult, and, as even the magnetic portion of the sands contains some titanic acid, it is thought advisable, in the present analyses, to represent the whole of the iron in these ores as protoxyd, giving, at the same time, the amount of metallic iron, and, in the case of the magnetic portions, the magnetic oxyd corresponding thereto. In the non-magnetic portion of the Bersimis sand, however, as will be seen, the proportions of the two oxyds of iron were determined. The magnetic grains having been removed from the above sample of Moisie ore, the non-magnetic portion gave 58.20 of protoxyd of iron, 30.74 of titanic acid, and 6.14 of insoluble residue.

Further and more complete analyses were subsequently made of the washed ore from the Moisie iron-works, which, as already stated, contained 52.0 per cent. of magnetic grains. These were analyzed separately, (II) while the non-magnetic portion gave me the results under III. Sulphur and phosphorus are present in this sand in very small quantities, the determinations of Mr. Broome giving for the washed mixed ore .070 per cent. of sulphur and .007 of phosphorus.

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	II.	III.	I A.
oxyd of iron	85.79	58.38	71.08
ic acid.....	4.15	28.35	16.55
of manganese.....	.40	1.10
.....	.90	.95	....
able	1.95	8.75	5.35
	<u>93.19</u>	<u>96.13</u>	<u>....</u>
stic oxyd of iron.....	92.68	....	....
lic iron.....	68.73	43.85	55.27

of the analysis II, if the iron be calculated as magnetic oxyd,

The composition of the mixed ore, if we suppose II and III d in equal proportions, would be as under I A, which agrees h the analysis I, given above.

s.—The iron sand of Bersimis, as already described, contained er cent of magnetic grains ; the analysis of this portion is given

	IV.
Protoxyd of iron.....	85.56
Titanic acid.....	3.40
Oxyd of manganese.	undet.
Lime	traces.
Magnesia .....	...
Insoluble	3.85
	<u>92.81</u>
Magnetic oxyd of iron.....	92.44
Metallic iron	66.56

of the analysis, if the iron be calculated as magnetic oxyd, is
 he non-magnetic portion of the Bersimis sand was dissolved in
 e acid, out of contact with oxygen, and the amounts of protoxyd
 rd of iron were separately determined. The analysis gave me

	V.
Protoxyd of iron.....	24.66
Peroxyd of iron	22.24
Titanic acid.....	26.95
Oxyd of manganese	1.10
Lime	1.12
Magnesia .....	.72
Insoluble	23.80
	<u>100.59</u>
Metallic iron	34.94

Mingan.—The iron sand from the mouth of the St. John river, at Mingan, contained 48.3 per cent. of magnetic grains, whose analysis is given under VI, while that of the non-magnetic portion of the ore is found under VII. *Mingan sand.*

	VI.	VII.
Protoxyd of iron.....	80.46	46.31
Titanic acid	6.50	31.60
Oxyd of manganese .....	.52	1.35
Lime .....	.75	1.06
Magnesia.....	.70	.50
Insoluble.....	4.20	15.50
	<hr/> 93.13	<hr/> 96.32
Magnetic oxyd of iron	86.92	....
Metallic iron.....	65.58	36.00

The sum of the analysis VI, if the iron be estimated as magnetic oxyd, is 99.59.

In the above analyses of the iron sands it will be remarked that the magnetic portion retains a little adherent silicious matter, and small amounts of titanium, both of which vary in the sands from different localities, although the separation by means of the magnet was in all cases effected with the same precautions. Observations and experiments on other samples of these sands go to show that different layers from the same locality vary, not only in the proportion of silicious sand, but in the relative proportions of magnetic and titanic ores and of garnet. This might be expected when we consider that the differences in density between each of these constituents of the sand, should, under the influence of moving water, lead to their partial separation from each other. *Varying composition.*

A specimen of iron sand from Quogue, on the south side of Long Island, near New York, where these sands are about to be employed for the manufacture of steel, closely resembled those of Bersimis, and contained 81 per cent. of magnetic grains. The unpurified ore, which was mingled with a considerable amount of quartz sand, and some garnet, amounting together to about 17 per cent., gave by analysis about 40 per cent. of iron, and 15 per cent. of titanium, besides a proportion of manganese greater than the iron sands from the lower St. Lawrence.

ON THE MANUFACTURE OF IRON AND STEEL BY DIRECT METHODS.

Although by far the greater part of the wrought iron and steel now used in the arts is made from cast iron produced in the blast-furnace,

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story of iron-making shows us that in early times malleable iron, and steel, were obtained directly from certain ores, without the previous fusion of cast iron, and without fusion. The manufacture and use of steel, in fact, date only from a comparatively recent period. The process of the direct conversion of iron ores to the metallic state in small furnaces. In certain districts of India the amount of malleable iron thus produced is very considerable, and much of it is manufactured into steel; the furnaces used are small in size, and produce not more than from five to forty pounds of iron in a day, with the labor of three or four men and with a great waste of ore and of charcoal. The rich native ores, finely pulverized, or the grains of iron ore obtained by washing the ore of certain districts, are heated with charcoal in small furnaces, until they are reduced and yield masses of malleable metal. Somewhat similar methods of making malleable iron have long been known in various countries of Europe, where, under improved forms, they are still followed, and have hence been brought to America. Of these furnaces for the direct fusion of ores into malleable iron, the five known in Europe are the Catalan and Catalan forges, the German bloomery forge, the Osmund furnace, and the German Stückofen or high-bloomery furnace, which latter has high walls, and approached in form to the modern blast-furnace, of which it seems to have been the immediate precursor. For a detailed description of these various furnaces, and the mode of working them, the reader is referred to Dr. Percy's learned work on the metallurgy of iron and steel. Inasmuch, however, as furnaces related to the German bloomery are still largely used on this continent, and promise to become of considerable importance to Canada, it will be well to describe briefly some points in the history of these various European furnaces.

Of these, the best known is the Catalan furnace or forge, so called from the province of Catalonia, in Spain, where it was formerly much used, as also in the neighboring parts of France. The department of Ariège, in 1810, had in operation forty-nine of these furnaces, producing 5800 tons of metal, of which 215 tons were a crude kind of steel, the remainder being malleable iron. The process has there, however, since probably fallen into disuse. Similar forges continue to be employed on the Italian peninsula, and, in 1850, there were forty of them in operation in the province of Corsica, where they were used for the treatment of specular iron ore obtained from the island of Elba. In the French Pyrenees, however, (in the department of Ariège) the ore generally used in these furnaces is a dark brown oxyd, holding from forty to fifty per cent. of iron, and differing in its character to the bog ores of the province of Quebec. The Catalan forge consists of a rectangular hearth, constructed chiefly

of heavy iron plates, which, in the largest size, is about forty by thirty-two inches, and from twenty-four to twenty-seven inches deep, or from fourteen to fifteen inches below the twyer. In some districts, however, furnaces of not more than one-half these dimensions are built. The pressure of the blast employed does not exceed $1\frac{1}{2}$ or $1\frac{3}{4}$ inches of mercury, and the twyer is directed downwards, at an angle of thirty or forty degrees. The wall facing the twyer, slopes outward towards the top, and in working, the greater part of the charge of ore is heaped against it, and occupies from one-third to one-half of the cavity of the furnace, the remaining space being filled with ignited charcoal. The ore is previously broken so that the large lumps are not more than two inches in diameter, while from one-third to one-half of the material will pass through a screen, ^{Mode of working.} the bars of which are four-tenths of an inch apart. This finer ore is thrown on the surface of the fire, from time to time, during the operation, which is conducted with many precautions as to regulating the blast, stirring, supplying the fine ore and coal. At the end of six hours, in the ordinary routine, there is withdrawn from the bottom of the furnace an agglomerated mass of reduced but unmelted iron, which is then forged into blooms or bars. The operation, lasting six hours, consumes, in one of the larger sized forges, about $9\frac{1}{2}$ cwt. of ore and $10\frac{1}{2}$ cwt. of charcoal, and yields 3 cwt. of bar iron. According to another calculation, there are required for the production of 100 pounds of iron, 340 pounds of charcoal and 312 pounds of an ore containing from 45 to 48 per cent. of iron. Of this about seven-tenths are obtained in the metallic state, the remaining three-tenths passing into the slag. 100 pounds of ore yield 31 pounds of bar iron, and 41 pounds of slags, which are dark-colored basic silicates, very rich in oxyd of iron.

The Corsican forge is a more primitive form of furnace than the Catalan, ^{Corsican forge.} and without interest, except so far as it belongs to the history of iron-working. It is said to have consumed more than 800 pounds of charcoal for the production of 100 pounds of iron. Some few of these forges were still in operation in Corsica forty years since.

Another form of furnace, described by Dr. Percy under the name of the Osmund furnace, was used during the last century in Norway and Sweden. ^{Osmund furnace} It was a rude hearth, with walls around it, and an opening in one of the side near the tap-hole, which was built up with stones, and taken down when it was required to extract the loup or mass of reduced iron. This furnace was not capable of yielding more than $1\frac{1}{2}$ tons of iron in a week, but is still used in Finland, and it is mentioned as a curious fact, that certain bog ores which contain so much phosphorus as to yield but a poor and hot-short iron by treatment in the blast-furnace, and subsequent decarburization, afford a good malleable iron when reduced by the direct method,

in the Osmund furnace ; a result which appears to be due to the fact that the phosphorus, which is reduced and passes into the iron, in the blast-furnace, escapes reduction at the lower temperature of the Osmund furnace.

Improved Catalan, or Genevieve forge.

An improvement in the Catalan forge has been introduced in the province of Genoa, in northern Italy, and consists in the utilization of the waste heat, which is made to roast, and subsequently partially to reduce, the ore before treating it in the forge. For this purpose a flat-bedded reverberatory furnace, so constructed as to receive, at one end, the flame from the forge, was provided at the other end with a charging-door, within and above which was a vertical chamber, communicating with the chimney, and having a side-door, and a grating at the bottom. Upon this grating, the ore, a specular oxyd containing 68 per cent of iron, was laid, and exposed to the heat, which roasted it, expelling a small portion of sulphur. After being thus heated for some time, it was withdrawn and thrown into water, by which process it was rendered friable. Being then broken into small lumps and coarse powder, it was spread out evenly on a layer of broken charcoal, with which the bottom of the reverberatory hearth had previously been covered, and was here exposed to the heating effect of the waste flame from the forge, during the whole time of working a charge in the latter. In this operation the bed of charcoal was consumed, and the ore lost ten or twelve per cent. of its weight, being partially deoxydized. Some scraps of cast iron or wrought iron were then added to the half-reduced ore, and the whole mass, by means of a rabble introduced through the charging-door, was pushed forward into the forge-hearth. In this way, five heats, instead of four, could be worked off in twenty-four hours, with great economy in charcoal, improvement in the quality of iron, and a somewhat greater yield. Separate furnaces were also constructed in connection with these works, for reheating the iron to be drawn out into blooms, and the waste heat from these was also employed in heating reverberatories, as above explained.

Working results

One of the Catalan forges, with these improvements, yields in a week of six days, thirty heats of iron, with an average consumption, for each heat, of 95.30 kilogrammes of ore in lumps, 68.50 of ore in powder, 31.75 of wrought-iron scrap, and 254.00 of charcoal, with a yield of 143.00 kilogrammes of bar iron. This is equal to 1575 pounds of iron in twenty-four hours, with a consumption of 2794 pounds of charcoal. It is, however, to be noticed that about 22 per cent. of this product, or 349 pounds, was added in the condition of wrought-iron scrap, whose reworking would consume comparatively little charcoal. Making a liberal allowance for this, we may fairly consider the work of the furnace as nearly equal to the production, from the ore, of 1400 pounds of iron, which is at the rate of 50

pounds of iron for 100 pounds of charcoal consumed, and is about the result obtained with the American bloomaries, to be noticed farther on; while the proportion obtained with the unimproved Catalan forge, described above, is only at the rate of 30 pounds of iron to 100 pounds of charcoal.

Mention has already been made of the German high-bloomary furnace, or Stückofen, which is of no particular interest in this connection, and is not to be confounded with another furnace known simply as the German bloomary. This was formerly used in Silesia and the Palatinate, and is described at some length in the classic work of Karsten, written a little more than half a century since (1816), but is dismissed with a few words in Bruno Kerl's treatise on metallurgy, published in 1864 (*Huttenkunde*, iii, 427), from which its use would seem to be nearly or quite abandoned in Germany. According to Karsten the German bloomary consisted of an iron pot, or a box of iron plates, in either case lined with refractory bricks, and having an internal diameter of from fourteen to twenty-one inches, and the same depth, the dimensions varying with the fusibility of the ore, the force of the blast and the quality of the coal. The twyer was horizontal; the furnace having been filled and heaped up with burning charcoal, the ore was thrown upon the fire by shovels-full at a time; this process was continued, the supply of fuel being renewed, until a loup of sufficient size had been formed at the bottom of the hearth, as already described in the Catalan method. When the blast is too intense, or the coal very dense, it may happen that the reduced iron becomes carburetted to such an extent as to produce steel-like iron, or even molten cast-iron, instead of a loup of soft malleable iron. A similar state of things sometimes occurs in the Catalan forge, and is occasionally taken advantage of to obtain an imperfect kind of steel.

German bloomary.

From the above description it will be seen that the method by the German bloomary differs from that by the Catalan forge, in the fact that, in the latter, the greater part of the charge of ore is placed, at the commencement of the operation, in a coarsely broken state, on the sloping wall of the furnace, opposite to the twyer, while the remaining portion is subsequently projected, in a more finely divided condition, upon the surface of the fire. In the German method, on the contrary, the whole of the ore is reduced to this finer condition, and is added by small portions, a plan which dispenses with the charging of the furnace after each operation, as in the Catalan method, and permits of a continuous working, interrupted only by the withdrawing of the lous from time to time. The German bloomary, in an improved form, is extensively used for the reduction of iron ores in the United States, where it is known by the name of the bloomary fire, the Jersey forge, or the Champlain forge, and is also frequently called

Distinguished from Catalan.

the Catalan forge, from which, as has already been shewn, it is distinct in form, and still more distinct in the manner in which it is worked. Before proceeding to describe in detail the American bloomery fire, it will be well to notice some of the advantages of the direct methods of extracting iron from its ores, and to point out the conditions under which they may be used with advantage.

Karsten remarks that the iron obtained by a direct process is often of a superior quality, for the reason that the separation of the foreign matters from the ore is effected by a kind of liquation, rather than by complete fusion; and, moreover, that certain impurities, which would be reduced and unite with the iron at higher temperatures, are carried off by the slags, in an unreduced state, at the lower heat of the open forge. A striking illustration of that has been given above, in speaking of the Osmund furnace, and its use in Finland. For these reasons Karsten was of the opinion that in some regions, and with certain ores, the direct process was, perhaps, more advantageous than the use of the blast-furnace combined with the reverberatory-hearth. This, however, was half a century since, and, in the meantime, great improvements have been made in the manufacture of cast iron, as well as in puddling or otherwise treating the pig-metal. In view of all these facts, and of the great facilities for transportation at the present day, Dr. Percy observes (in 1864), "that there can only be comparatively few localities in Europe where these (Catalan) forges can be conducted with profit. In mountainous regions abounding in rich iron ores and wood suitable for charcoal, and still inaccessible to railways, the Catalan process may hold its ground, but certainly not in localities where it is unprotected by high rates of carriage, or other circumstances, from competition with iron smelted and manufactured by modern processes. Its advantages are that the outlay and floating capital required for a forge are inconsiderable, and the consumption of charcoal is comparatively small."—Percy, *Metallurgy of Iron and Steel*, page 311.)

The German bloomery process was probably introduced into North America early in the last century. Among the forges in operation in New Jersey and Pennsylvania in 1856, Lesley, in his *Iron Manufacturers' Guide*, mentions one as having been established in 1733, and another in 1725. These were, perhaps, bloomeries for the conversion of pig-iron by the Walloon method, which was used in this region at an early date; but it is evident, from facts cited already, page 263, that the treatment of pulverized iron ores in the German bloomery fire was already practised in Connecticut as early as 1761. It was, probably, the coming of German immigrants which led to the use of the German rather than the Catalan forge, which, so far as I can learn, is unknown, at least, in the northern and eastern parts of the United States. Various improvements have

been, from time to time, made in the construction of the furnaces, the most important of which has been the introduction of the hot blast. Favored by supplies of rich ores, and protected, to a certain extent, from foreign competition, by duties on imported iron, the manufacture of iron by this method has been widely extended over the United States, and has assumed considerable importance. In the districts where it was first introduced, including northern New Jersey and the adjacent portions of New York and Pennsylvania, the bloomary process is falling into disuse, since wood has become scarce, and extensive workings of coal in the vicinity, with the great facilities for transportation, have rendered it more profitable to treat the ores in the blast-furnace than in the bloomary fire. In northern New York, on the contrary, the use of the direct process appears to have considerably extended during the past few years.

Bloomaries in
United States.

The works for producing iron directly from the ores, by the present method, are known in the United States as forges or bloomaries, and sometimes consist of twenty forge-fires or furnaces, but in many cases of not more than two or three. According to the report prepared by Mr. Charles E. Smith, for the *Iron Manufacturer's Guide* (page 760), and published by authority of the American Iron Association, there were, in the year 1856, produced directly from the ore, 28,638 tons of malleable iron, from 203 forge-fires. Of these, 42 were in New York, 48 in New Jersey, 36 in North Carolina, 14 in Alabama, and 50 in Tennessee. There were besides, at that time, 35 abandoned fires, of which not less than 29 were in New Jersey. The average production from each forge-fire was thus 141 tons. Since that time I have no means of knowing the condition of this manufacture in the south and west. In New Jersey, for reasons already given, the direct method is almost abandoned, while in northern New York, on the contrary, it has greatly increased. Instead of the 42 fires reported in 1856, there were, in 1867, according to the Iron and Steel Association Bulletin, 136 fires in activity in Essex and Clinton counties, the principal seats of this industry. The aggregate product of these forges was supposed by a competent authority, in 1868, to be nearly 40,000 tons of malleable iron, a large portion of which is consumed at Pittsburg for the manufacture of steel by cementation, a process for which this iron is eminently fitted, and for which that reduced from the ore of the Palmer ore-bed, near Keeseville, is especially prized. Two establishments in the neighborhood work the ore of this deposit; one, that of Messrs. Rogers, of Ausable Forks, had 21 fires, and the other, that of the Peru Company, of Clintonville, 18 fires, in 1868.

New York
forges.

The direct method of reduction cannot be applied to poor ores, which, to yield good results in the German or Catalan forge, should not contain much less than 50 per cent. of iron, while much richer ores are to be pre-

d. Some of the iron ores of North America consist of an aggregate of crystalline grains of magnetic oxyd, mingled with so large a proportion of calcareous or silicious matter as render them unfit for the bloomery fire, without purification. This is generally effected by crushing and washing after a previous partial calcination, and leaves the ore in a coarsely granular state, which would not be adapted to the Catalan, although well adapted to the German or American method. This condition of things is illustrated by the ore of the famous Palmer bed, just mentioned. I was informed at the works of Messrs. Rogers, that from four to five tons of the crude ore were required to make a ton of blooms. The ore, as it came from the mine, is chiefly magnetite, with grains of white quartz, and, in small portions, of flesh-red feldspar. It is slightly roasted, to render it friable, then stamped and passed through screens with openings of about one half of an inch, and purified by washing. Two tons of the washed ore were required to make a ton of blooms. I took what seemed an average sample of the crushed ore from the stamps, and having further reduced it so that it would pass through the meshes of a sieve having sixteen holes to the square inch, carefully separated the magnetic from the non-magnetic portion, which contained a proportion of grains of specular iron ore, but was free from quartz. The magnetic portion equalled 45 per cent. of the whole. The non-magnetic portion of the dressed ore, such as supplied to the bloomeries, was dressed in the same manner, by further crushing, and separation by the magnet, and contained 64 per cent. of magnetic ore; the non-magnetic portion, consisting of silicious matters, holding a considerable proportion of grains of specular iron, which would probably raise the amount of oxyd of iron in a sample of the water-dressed ore to about 85 per cent., or a little over 80 per cent. of metallic iron. In other districts of northern New York, as in the vicinity of Port Henry, the crude ores are richer than those just mentioned, and often contain very little extraneous matter, so that the operation of washing may sometimes be dispensed with. At the New Russia Furnace, in Moriah, the ore, which is mingled with a little quartz, is piled in piles, with wood, during two or three days, then crushed and dressed as above described. Two tons of the crude ore yield one and a half tons of dressed ore, which is calculated to give one ton of blooms. The washing process removes not only the foreign matters, but a portion of fine ore, which is lost, and may be seen accumulated in the vicinity of the washing. The bloomers, as the iron-makers are called, object to this fine ore, being unfit for use, but it will be seen further on that this prejudice is without foundation, and that the finer grains can be used with advantage, as they are now rejected, and considerable loss is thereby incurred. The magnetic ores of Lake Champlain are exported to Vermont, where, for several years, a few bloomeries have been supplied with iron ore from

the west side of the lake. Three forge-fires were, in 1868, in operation at Salisbury, and three at East Middlebury, Vermont, five miles from the Middlebury station on the Rutland and Burlington Railway. The ore for this purpose is brought by water from Port Henry or Port Kent to Burlington, and thence by rail to Middlebury station. This is brought partly in lumps, which are crushed and washed at the forge, and partly dressed to a high degree of purity, and ready for use.

Vermont
forges.

Overman is, so far as I am aware, the only writer who has given any account of the American bloomary process. In his *Treatise on Metallurgy* (sixth edition, 1868, page 541), will be found a description, accompanied by figures. My own observation, as here given, have enabled me to verify the general correctness and trustworthiness of Overman's statements with regard to this subject.

The bloomary hearths or furnaces in different localities exhibit some little variations in size and in the details of their arrangements. The size of the hearth varies from twenty-seven by thirty to twenty-eight by thirty-two inches, and the height, from twenty to twenty-five inches above the twyer, and from eight to fourteen inches below. The sides are made of heavy cast-iron plate, and the bottom, although often of beaten earth or cinders, is, in the best constructed hearths, also of iron, made hollow, and kept cool by a current of water, which is made to circulate through it. In the East Middlebury forges this bottom-plate is four inches thick, and has within it a hollow space of two inches. The side-plates, which slope gently inwards, in descending, and rest on ledges on the bottom-plate, are one and a-quarter inches thick. A water-box, measuring twelve by eight inches, is let into the twyer-plate, and a stream of cold water circulates through this box, and through the bottom-plate, as well as around the twyer. The length of the hearth, from the twyer-plate to that opposite, is twenty-four and a half inches, and the breadth from front to rear is twenty-nine inches. The twyer enters twelve inches above the bottom, and is inclined downwards at such an angle that the blast would strike the middle of the hearth. The opening of the twyer has the form of the segment of a circle, and is one inch high by one and three-quarter inches wide. In front of the furnace, at sixteen inches from the bottom, is placed a flat iron hearth, eighteen inches wide. The side-plate beneath it is provided with a tap-hole, through which the melted slag or cinder may be drawn off, from time to time. The iron plates used in the construction of these furnaces last for two years. In the furnaces used at the New-Russia works in Moriah, already mentioned, the iron bottom-plate is not made use of, the bed consisting of beaten-down earth or ashes. These furnaces have a depth of twenty-four inches, and measure twenty by thirty-two inches at the top, but are somewhat smaller towards the bottom; the twyer, in these, enters one of the narrower

Bloomary
hearths.

sides of the rectangle. While these are somewhat smaller than the forges at East Middlebury, those lately constructed at Moisie are somewhat larger, measuring thirty by thirty-two inches, the bottom-plate being fourteen inches below the twyer, which is placed nearly horizontal, but of the same size as that described above.

The blast employed in the American bloomaries has a pressure of from $1\frac{1}{2}$ to $1\frac{3}{4}$ pounds, and is heated by passing through a series of cast-iron tubes, placed in an upper chamber, above the furnace. These are in the form of inverted siphons, each limb being about seven feet in length, their exterior diameter seven, and their interior diameter five inches. At the East Middlebury forges the air is made to pass successively through three such tubes, heated to dull redness, and attains a temperature estimated at from 550° to 600° Fahrenheit. The use of the hot blast hastens the operation, and enables the workmen to produce a larger quantity of iron in a given time, than with the cold blast, while, at the same time, it effects a considerable saving in fuel. It is said that where 240 bushels of charcoal will produce a ton of iron with the hot blast, 300 bushels of the same coal would be consumed if the cold blast were used. The quality of the metal is supposed to be deteriorated if too hot a blast is used. With judicious management, however, the use of the hot blast offers great advantages over the cold blast, and has been very generally adopted in the American bloomaries.

Working of
bloomaries.

The working of these furnaces is conducted in the following manner: The fire being kept active, and the furnace heaped with coal, the coarsely pulverized ore is scattered, at short intervals, upon the top of the burning fuel, and in its passage downwards is reduced to the metallic state, but reaches the bottom without being melted, and there accumulates, the grains agglomerating into an irregular mass or loup, as it is termed, while the earthy matters form a liquid slag or cinder, which lies around and above it, and is drawn off from time to time through the openings in the front plate. At the end of two or three hours, or when a sufficiently large loup is formed, this is lifted by means of a bar, from the bottom, brought before the twyer for a few minutes, to give it a greater heat, and then carried to the hammer, where it is wrought into a bloom; the bloomary fire itself being generally used for re-heating. This operation concluded, the addition of ore to the fire is resumed, and the production of iron is thus kept up, with but little interruption. In this way, a skilled workman will, with a large sized furnace, bring out a loup of 300 pounds every three hours, thus making the produce of the day of twenty-four hours, 2,400 pounds of blooms; in some cases, it is said, 1,500 pounds, and even more, are produced by twelve hours working.

In this connection may be mentioned an arrangement, described and

figured by Overman, in which the waste heat from the forge, (or rather from two forges united,) passes into an oven or stove, placed at a level above the bloomary-fire, and there serves to re-heat the blooms, when it is required to draw them out into bars. A set of small blast-pipes, placed just above the forge, serves to heat a portion of air, which is led into the oven, and there burns any escaping carbonic oxyd gas. The air and gases from the re-heating oven are afterwards employed to heat the blast for the bloomary hearth, in the usual manner. I have not seen this arrangement in operation.

The following observations will serve to give some notions of the working of the bloomary process in the United States. At the Ausable works, as already stated, the somewhat lean ores are dressed so as to yield about fifty per cent. of iron, two tons of ore being required for one ton of blooms, while at the New Russia forges, in Moriah, near Port Henry, where a nearly pure magnetite is employed, three tons of the dressed ore are stated to yield two tons of blooms. When it is considered that perfectly pure magnetite contains only 72.0 per cent. of iron, this proportion of 66.6 per cent., said to be obtained, shows a great economy in working. These figures, furnished me by the proprietor of the forges, Mr. Putnam, were afterwards confirmed by Mr. Pearson, the director of those at East Middlebury, where the very rich ores from the same region are treated. The dimensions and construction of the New Russia forges have already been given. The pressure of blast employed was from $1\frac{1}{2}$ to $1\frac{3}{4}$ pounds, and the average produce of iron for each fire, 2,400 pounds of bloom-iron in twenty-four hours; the amount of charcoal consumed being from 250 to 300 bushels to the ton of blooms produced, and the weight of the charcoal from sixteen to eighteen pounds to the bushel.

At East Middlebury, where, as just stated, the conditions are very similar, the estimated consumption of charcoal was 270 bushels to the ton of blooms, a result which is the mean of the figures obtained at the New Russia forges. Some of the ores here used contain a little phosphate of lime, and it was observed that when too hot a blast was used, although the production of metal was rapid, the iron from these ores was hot-short, while with the cold blast, formerly employed, the iron, although produced more slowly, was never hot-short. The force of the blast at these forges was equal to one and three-quarter pounds, and even two pounds to the inch. Mr. Pearson, the director of the East Middlebury forges, made, in the autumn of 1867, experiments on several tons of the iron sands from Seven Islands, page 266, and succeeded in obtaining from them about three-eighths of their weight of good iron. He, however, found it necessary, in order to treat these fine sands, to reduce very much the force of the blast, an experience which has been confirmed by the practice at Moisie. It

appears to be from ignorance of this fact, that the bloomers of New York had always rejected the fine sandy ore separated during the process of washing, as being unsuited for treatment in the bloomary fire.

Moisie forges.

At Moisie, although eight forges have been constructed, but four of them were in operation at the time of my visit in August, 1868, and the same number, I am informed, in October last, two of the furnaces not having yet been completed. A reverberatory furnace has, since my visit, been constructed, in which it is proposed to re-heat the louns for the second hammering, instead of returning them, as in most cases is done, to the forge-fire for that purpose. The opening of the twyers used measured one inch by one and seven-eighths; they were inclined downwards at a very small angle, it having been found by experience that the considerable inclination which is used with the coarser ores cannot be advantageously employed with the fine sands. In like manner, as remarked above, it has been necessary to reduce the force of the blast, to from $\frac{7}{8}$ to $1\frac{1}{4}$ pounds, the average working-pressure being about one pound to the inch. According to the latest accounts, there were, in October, four hearths in regular operation, requiring four bloomers, one assistant to furnish coal, etc., and one hammerer, being six men in all for each shift of twelve hours. Each hearth furnished eight louns daily, and the aggregate yield of iron was estimated at three tons, or three-quarters of a ton for each hearth, every twenty-four hours. The consumption of charcoal was 1400 bushels daily, being at the rate of 466 bushels to the ton of blooms, or 350 bushels to each fire. This charcoal is chiefly produced from spruce and fir, with some admixture of birch, the wood being mostly small, and the weight of the coal is stated to be fifteen pounds to the bushel. This gives a consumption of 6990 pounds of charcoal for the production of 2240 pounds of blooms, being at the rate of 3.12 pounds of charcoal for the pound of iron. If we compare this result with the figures given above, for those forges which treat nearly pure magnetic iron ores, we find that to produce a ton of blooms there are consumed, at East Middlebury, 270 bushels, and at New Russia from 250 to 300 bushels of charcoal, weighing from sixteen to eighteen pounds to the bushel. If we assume, in both cases, the greater weight, of eighteen pounds to the bushel, we have for 250 bushels, 4500 pounds, and for 300 bushels, 5400 pounds of charcoal, the former corresponding to 2.01 pounds, and the latter to 2.41 pounds of charcoal to the pound of iron, or, taking the mean of the two, 2.21 pounds, as compared with the 3.12 pounds said to be consumed at the Moisie works.

Consumption
of charcoal.

Sizes of
hearth.

If now, we consider the relative sizes of the different bloomary hearths, we find them to be as follows:—

New Russia.....	20 × 32 inches = 6,400 square inches.
East Middlebury.....	24 × 29 " = 6,960 " "
Moisie.....	30 × 32 " = 9,600 " "

The area of the Moisie hearths is, then, in round numbers, one and a-half times that of the others, and, with an equally powerful blast, they should consume one-half more charcoal. This increased size is, however, counter-balanced by the feebler blast, and we find that each fire at Moisie consumes, in twenty-four hours, 850 bushels of charcoal, equal to 5250 pounds, which, from the calculations already given for the New Russia forges, should produce, with an ore such as there treated, 2875 pounds of iron. In fact, the Moisie forges, according to the data before us, with an area one-half greater, consume daily the same weight of charcoal as those of New Russia, and produce only two-thirds as much iron.

I have very recently been informed that, with careful management, it has lately been found possible so far to reduce the consumption of fuel at Moisie, that a ton of blooms can be made with 850 bushels of properly prepared charcoal. The consumption of ore, which formerly amounted to three tons or more for a ton of blooms, is also said to have been considerably reduced, the daily production of iron from each hearth, however, remaining the same as before.

The cause of this small production of iron, as compared with the area of the furnace, and with the consumption of fuel, is not, in my opinion, to be found either in the reduced force of the blast or in the mechanical condition of the ore. A great heat is not required for the reduction of the oxyd of iron to the metallic state, and other things be equal, the finer its subdivision, provided it be not dissipated by the blast, the more rapid and more complete should be its conversion to the condition of metal, by the action of the reducing gases, as it passes downward through the mass of burning charcoal. Such coarse grains of ore as pass, incompletely reduced, through the ignited fuel, and in this state reach the slag below, have no chance of further reduction in the forge. Hence we may conclude that, the fineness of the ore, should, under favorable conditions, render the reduction more complete.

The principal cause of the small yield of the Moisie furnaces is apparently to be found in the incompletely purified condition of the ore. It will be seen in the detailed analyses on page 267, that the iron sand, as now prepared for the forge, may, by the use of the magnet, be divided into two nearly equal portions. One of these is magnetic, and consists, for the greater part, of magnetic oxyd; it contains over two-thirds its weight of iron, and is nearly equal in richness to the magnetic ore used in the New Russia forges. The other half is a highly titaniferous oxyd, mixed with more or less silicious matter, and containing only 44 per cent of iron; and its admixture with the magnetic oxyd, which reduces the proportion of iron in the whole to 55 per cent, appears to be not merely useless, but actually prejudicial.

Causes of the smaller yield.

Nature of ore.

When an impure ore of iron is treated in the blast-furnace, certain substances, called fluxes, are added, which form fusible combinations with impurities. Thus, if the ore contains silica, a sufficient quantity of lime is smelted with it, and a silicate of lime is formed, while the oxyd of iron, being left free, is wholly reduced to the metallic state. In the direct method, on the contrary, no fluxes are used, and if silica be present in the ore, it combines with a portion of the oxyd of iron, forming a silicate of iron, which melts into a slag or cinder, from which the iron cannot be separated in the forge. Thirty parts of silica will, in this way, unite with seventy-two parts of protoxyd of iron, equal to fifty-six parts of metallic iron. In the case of the somewhat silicious ores of the Pyrenees, treated in the Catalan forge, we have seen that three-tenths of the iron present in the ore pass into the slag, and the loss would be much greater did not these ores hold a considerable proportion of manganese, lime and other bases, which help to satisfy the affinity of the silica, and to leave the iron free. Such substances as these, play the part of fluxes with a silicious ore, but if they are wanting, a portion of the oxyd of iron itself is consumed for the purpose, forming, in fact, the only flux for the silicious impurities, when such an ore is treated by the direct method in the bloomary fire. Whenever, in the Catalan forge, the American bloomary fire, or any other direct method, we have to treat an ore containing free silica, provided other bases are not present, we must always allow oxyd of iron, in the proportion already indicated, for the saturation of the silica, being at the rate of nearly two parts of metallic iron for each part of silica present in the ore. It is for this reason, it may be remarked, that kiln-burned charcoal is to be preferred, for the bloomary hearth, to charcoal made in piles; the latter being generally more or less impure from adhering silicious earth, which, by combining with oxyd of iron, causes a waste of the ore.

The quartzose sand which is mixed with the iron sands, is nearly pure silica, and the oxyd of titanium which they contain, appears, from the analyses of slags given below, to require, for fluxing it, as much oxyd of iron as the silica itself. These slags, in case no other bases than oxyd of iron are present, should approach very closely to the composition of a tribasic silicate of protoxyd of iron, which, as already explained, contains 30 of silica to 72 of protoxyd of iron, or 29.40 per cent. of silica, and 70.60 of protoxyd, equal to 54.9 per cent. of metallic iron. The highly titaniferous slags produced at the Moisie furnaces, contain, in some cases, a still large proportion of oxyd of iron.

Of the following analyses, I is of a crystalline, black, brilliant magnetic slag, which contained cavities lined with large pyramidal crystals, apparently dimetric in form. It was produced at the Moisie forges in the autumn of 1867. II was a portion of the ordinary slag produced at the time of

my visit, in August, 1868, and was similar to the last, but somewhat vesicular, the cavities being lined with very small brilliant crystals. Both of these slags readily gelatinized when treated, in powder, with hydrochloric acid. The residual silica, however, showed a portion of grains of undecomposed ore, which was larger in the second specimen; it was, in each case, deducted from the analysis. The whole of iron in both of these slags is represented as protoxyd, and the results are compared with those of two analyses of the non-magnetic portion of the ore, copied from pages 267 and 268, and here given under III and IV.

	I.	II.	III.	IV.
Protoxyd of iron	67.14	52.31	58.20	56.38
Oxyd of manganese	undet.	2.04	.....	1.10
Lime	1.37	.....	.....	.95
Magnesia .....	.80	.18	.....	.....
Alumina .....	. . .	.56	.....	.....
Titanic acid	20.07	34.05	30.74	28.95
Silica	8.75	11.29	6.14	8.75
	<hr/> 98.13	<hr/> 100.42	<hr/>	<hr/>
Metallic iron	52.22	40.68	45.26	43.85

From a comparison of the above analyses it will be seen that the first slag contains more oxyd of iron than the non-magnetic portion of the ore; which, in the conditions of working, at the time the slag was produced, actually dissolved and carried away a considerable portion of the reducible ore. If we were to regard one half of the washed ore as composed of pure magnetic oxyd, this, were it wholly reduced, could only yield an amount of metallic iron equal to 36 per cent; but the magnetic ore, as we have seen, still retains more than 6 per cent of silica and titanic acid, which must be removed by fluxing with a portion of the oxyd of iron present, giving rise to a certain amount of slag. Meanwhile the non-magnetic ore, in melting, removed another portion of iron oxyd, so that when this slag was made, more than three tons of a mixed ore, having the composition above given, must have been consumed for the production of a ton of blooms; while, of the magnetic portion of the ore, one and a-half tons, or a very little more, would suffice. (In the production of the slag II the loss of iron was somewhat less.) This explains why the Moisie furnaces have yielded, when compared with those of New York and Vermont, so small an amount of iron for the labor employed and the fuel consumed. To produce a ton of iron it has been necessary to handle twice as much ore as is required in forges where a pure ore is treated, and moreover one and a-half tons, or more, of worthless material have been fused, and got rid of as slag, thus involving a great waste of fuel, as well as of labor. It may here be remarked that a portion of slag taken by me from the East Middle-

bury forges, contained according, to Mr. Broome's analysis, 48.2 per cent of iron (equal to 62.06 of protoxyd), and 16.70 of silica, besides 17.88 of alumina, and 1.82 of oxyd of manganese. The amount of slag produced by the rich ores which are treated at these forges, is comparatively very small.

It would seem probable that by a judicious management of the working, the waste of iron in the slags at Moisie, might be considerably reduced, and this result, we are assured, has lately been attained ; but it will still remain true, that a large amount of iron-oxyd must be consumed to flux the considerable proportions of silica and titanio acid, which are present in the mixed ore, even after careful washing.

Reduction in crucibles.

It should here be explained that the result would be far otherwise if this ore, with all its impurities, were to be fused in a crucible with carbonaceous matters, with, or even without proper fluxes. In the former case, as in a blast-furnace, the whole of the iron which it contains, amounting to not less than 55 per cent., might, by judicious admixture, be set free, and reduced ; and in the latter cases, without fluxes, it has been shown by Percy, that by fusion at a high temperature, in a crucible lined with charcoal, the tribasic silicate of iron, already noticed, gives up two-thirds of its iron, which is reduced to the metallic state, so that the amount of unreduced oxyd retained by the slag would be inconsiderable. From this it is evident that the results of fire-assays, or trials on a small scale in crucibles, cannot serve as a guide to the working of iron ores in the direct method.

A certain amount of lime added to the ore, would doubtless reduce the waste of iron in the slags, and thus allow more iron to be obtained from the mixed ore ; but although such an addition is useful in the blast-furnace, it would require experiments to determine whether the practice could be advantageously introduced in working in the bloomary-hearth. In a region where the ore is so abundant and so cheap as it is at Moisie, the saving of iron is a consideration which should be subordinate to the economy of fuel and labor, and the most profitable way of working these iron-sands would seem to be by separating and rejecting the non-magnetic portion, by some apparatus like that described farther on.

Quality of iron.

The quality of the iron produced at the Moisie forges is superior. As the result of experiments made upon it in England, it is said to possess a tensile strength greater than that of Low Moor iron, and to work easily both hot and cold. It is now employed at Montreal for the manufacture of railway axles.

The fact that those objectionable elements, sulphur and phosphorus, occur in but very small quantities in the iron-sand of Moisie, has already been noticed. It is probably to the absence of these that the excellence of the Moisie iron is due. In a specimen taken from a bloom which was

made in my presence, at the Moisie forges, the presence of sulphur could be detected by delicate tests, but its amount was only .0094, or less than $\frac{1}{10000}$; while the quantity of phosphorus present was equal to .0184 per cent. This iron contained no trace of titanium in its composition, and a small mass of white crystalline cast iron, which had accidentally been formed in one of the forges, was equally destitute of titanium.

The cost of producing a ton of iron blooms directly from the ore, by the bloomary process, varies greatly with the price of the dressed ore, which will depend on the proximity of the mine to the forge, and the richness of the crude ore. Thus, the cost of the two tons of dressed ore employed to make the fine iron of the Ausable forges, was estimated by Mr. Rogers, in 1868, at not less than \$18.00, while the one and a-half tons of ore consumed at New Russia, would not probably cost more than one-half that sum. The following estimate made by a highly competent iron-master, in 1868, may serve as a guide to the cost of producing iron at that time in New York:—

2 tons of ore.....	\$10.00
300 bushels of charcoal @ 8c.....	24.00
Wages.....	9.00
General expenses.....	3.50
<hr/>	
Cost of the ton of blooms.....	\$46.50
<hr/>	

The above prices are in American currency, which, at that time, was equal to about $\frac{1}{10}$, making the gold-value \$87.20. The estimate of another manufacturer, in Clinton county, gave \$7.00 for wages. It will be observed, moreover, that the amount of charcoal, in the above estimate, exceeds the average consumption for the production of a ton of blooms, which may be taken at about 270 bushels.

To produce a ton of blooms from cast iron, in what is known in Sweden, as the Lancashire hearth, there are consumed, according to an authority cited by Percy, 23 cwt. of pig iron, and $\frac{1}{2}$ tons of charcoal. In New Jersey and Pennsylvania the conversion of the pig iron, is, for some purposes, effected by a somewhat similar process, which involves two operations, the melting in the running-out fire, and a subsequent treatment in the sinking-fire, as it is called, which is a bloomary forge very like that used for the ore in the direct method. To produce a ton of blooms in this way, there are consumed 24 cwt. of pig iron, and 100 bushels of charcoal, according to one authority, while another estimate gives 120 bushels; the quantity varying both with the quality of the crude metal, and the charcoal; while, with some arrangements, the consumption of fuel is much

greater. The mean of these, 110 bushels, at 18 pounds to the bushel, would give, almost exactly $\frac{1}{16}$ of a ton, the amount used in Sweden. The quantity of charcoal consumed for the production of a ton of pig iron in the United States varies greatly, but in the best constructed and more modern furnaces, like those of Michigan, with rich ores, will not exceed 130 bushels of charcoal of the above weight, which gives, for 24 cwt. of pig iron, 156 bushels. (See page 256.) This, added to 110, equals 266 bushels, the total amount of fuel required to produce a ton of blooms by means of the blast-furnace with the charcoal-finery. There would appear to be but little difference, so far as the consumption of the fuel is concerned, between the cost of producing bloom-iron by the direct and indirect methods just described. The first cost of the establishment for the former is, however, less, and this is probably one of the reasons which has led to the adoption of the direct method by the blooming forge in northern New York.

Purifying ores. The conversion of the oxyd of iron to the metallic state, under the influence of solid carbonaceous matter, or reducing gases, takes place at a temperature considerably below that at which the affinity of silica for the oxyd of iron is exerted. Even the compound of titanac acid with oxyd of iron is decomposed at a red heat in contact with hydrogen gas, the iron being wholly reduced to the metallic state. If it were possible to effect this reduction, and subsequently to eliminate the silica and titanac acid from the metallic iron, ores containing these impurities might be made available for the direct method of conversion; but the practical difficulties of effecting such a separation are such that the only available modes of treating such ores as contain considerable amounts of these impurities, are to smelt them in the blast-furnace with proper fluxes, or to effect as complete a separation of the impurities as possible, before submitting them to the process of reduction. This, in the case where heavy granular ores are mixed with quartz and feldspar, as for example, at the Palmer ore-bed, already noticed, is attained by washing away the lighter materials. Where, however, the impurity is chiefly titaniferous iron, as in the Moisie sands, the separation may be readily effected by means of magnets, a process which is equally advantageous where magnetic iron ore is mixed with lighter impurities, as quartz or silicious minerals.

The use of magnets for this purpose has long been taken advantage of, and various machines with permanent and with electro-magnets have been contrived. A simple and ingenious arrangement for this end, which has been invented and patented by Dr. F. A. H. Larue, of Laval University, Quebec, appears to be novel in the mode of its working, and is very efficient and cheap. The mixed sand or crushed ore is poured through a screen, into a hopper, the discharge of which is so arranged as to open and close at proper intervals of time, and, falling from this, is spread

in a thin and uniform layer, upon a series of aprons arranged, with interspaces, between two parallel endless bands, which pass over two horizontal cylinders. These aprons, charged with ore, are made, by the movement imparted to one of the cylinders, to pass from beneath the hopper, and under a series of permanent horse-shoe magnets, 800 in number, each capable of sustaining about five pounds weight, arranged upon transverse bars, in five rows of 160 magnets each. Beneath these is a tympan, covered with muslin, which, when the iron ore is passing beneath them, is in the contact with the poles of the magnets. So soon, however, as the magnetic portions of the ore have arranged themselves, by magnetic attraction, in adhesion to the under side of the tympan, and the apron has moved from beneath, and gone forward to discharge the non-magnetic portion of the ore at the foot of the machine, the tympan is momentarily withdrawn a short distance from the poles, and the adhering magnetic ore falls in the open space between two aprons, into a receptacle placed below. This process of loading and unloading the magnets can be repeated twice in each minute.

Larue's magnetic machine.

These machines, as now constructed, occupy a space of about six feet by five, and are four feet high; they are said to cost, at Quebec, at about \$500 each. One, of these dimensions, will, according to Dr. Larue, treat in an hour, three tons of sand holding one-third of magnetic ore, separating from it one ton, containing over ninety-nine per cent of magnetic grains. I have myself seen only a smaller machine, the first one constructed, which had a capacity of about one-half that just stated. The motive power required is very small, and the mechanism, as will be seen from the description, exceedingly simple. Dr. Larue observes, that, inasmuch as a rich sand may be passed through the machine as rapidly as a poor one, the yield is directly proportionate to the amount of magnetite present, so that a sand containing one-fourth as much as that above mentioned, would yield about six tons of purified sand in twenty-four hours. Even very poor sands may, probably, with this machine, be treated with advantage. The same process of purification may doubtless be applied with advantage, after crushing, to the preparation of lean massive magnetic ores for the bloomary fire, or for other direct methods for conversion into iron and steel. A process of partial reduction, at a low red heat, will render non-magnetic iron ores attractable by the magnet, a reaction of which Chenot long since proposed to take advantage, for the purification of such iron ores as are not naturally magnetic.

In accordance with the well-known fact that the reduction of oxyd of iron takes place at a temperature very much below that required for its subsequent carburization and fusion, it has been shown that the charge of ore in a blast-furnace is converted to the metallic state some time before it

Various direct
processes.

descends to the zone in which melting takes place. It forms, when reduced, a spongy mass, readily oxydized, which, by proper management, can be compressed and made to yield malleable iron, or by appropriate modes of treatment, may be converted into steel. This fact has been the starting point of a great number of plans designed to obtain malleable iron and steel, without the production of cast-iron and the employment of the processes of puddling and cementation. This, it is true, is attained in Catalan and bloomary forges, but the attention of many inventors has been, and still is, directed to the discovery of simpler, or at least of more economical methods of obtaining similar results. A short sketch of the various new processes will not be without value, as bearing upon the utilization of the iron ores of Canada, and especially of its iron sands.

Chenot's
method.

Of these, the method of Chenot is best known. His experiments seem to have been commenced about forty years ago, since we are informed that he had erected a large furnace for the direct treatment of the ores of iron, in 1831, although his results were not brought before the public until twenty years later, at the International Exhibitions of 1851 and 1855. I was a member of the International Jury at the latter, and had an opportunity of studying Chenot's process as then conducted, on an industrial scale, at Clichy, near Paris. A description by me of the process as then and there practised, will be found in the report of the Geological Survey for 1855-57 (page 397). Rich peroxyd ores were broken in small pieces, mixed with a portion of charcoal, and placed in large vertical rectangular muffles or retorts, enclosed in a gas-furnace, and heated to redness. The ore, after being reduced to the state of metallic sponge, passed downwards into an air-tight cooling-chamber, which was a continuation of the muffle, and when sufficiently cooled, was withdrawn. The spongy metal, thus obtained, was then exposed to a welding heat in a proper furnace, and formed into balls, which were afterwards treated like the balls from a puddling-furnace, and gave malleable iron. By impregnating the metallic sponge with oily and tarry matters, and afterwards expelling these by heat, a sufficient amount of carbon was fixed in the metallic sponge to convert it into steel. By grinding, compressing and melting this carbonized sponge, cast-steel of a superior quality was manufactured at prices which, it was claimed, were much below the cost of steel prepared by cementation of bar iron. This process was subsequently introduced in several places in France, Belgium and Spain, where it was applied to the manufacture of bar iron, and up to 1863 at least, was worked on a considerable scale at Baracaldo, in Spain, where, in 1859, about ten tons of iron were manufactured daily from iron sponge.

A very important modification of the process already described, in which the heating was effected externally and indirectly, consisted in the

internal or direct method of heating. In this the outer furnace and the admixture of charcoal with the ore were both dispensed with. The vertical reduction-chamber was filled with ore only, which was reduced by the action of currents of heated carbonic oxyd gas, obtained by forcing air, at a pressure equal to half an inch of mercury, through two generators filled with ignited charcoal. This mode of producing the sponge was found much more economical than that by indirect or external heating. The working results of the direct method, as carried on at Lamarade, in Spain, in 1863, are given by Percy; from which it appears that for the production of one ton of blooms, there were consumed 1.87 tons of charcoal. The greater part of the fine Swedish iron used at Sheffield for the manufacture of steel, is produced from charcoal-made pig, treated in a charcoal-finery, known as the Lancashire hearth, and is obtained with a consumption of charcoal, which, for the united processes of reduction and refining, amounts to 1.90 tons for the ton of blooms, a result almost identical with that of the process of Chenot. (Percy, *Metal-lurgy*, pp. 342-596.) The modified Catalan forge, and the American bloomary fire, as we have seen, produce malleable iron with a consumption of charcoal which is not very much greater, and with a simpler, and probably less expensive apparatus than that required for the Chenot process; while the method by the blast-furnace permits of the use of ores which are unfit for treatment by any of these direct processes.

Chenot's direct
heating.Comparative
cost.

The patents granted to Clay, in England, in 1837 and 1840, were for the manufacture of malleable iron by a process essentially the same with Chenot's earlier method of indirect or external heating. According to Clay, hematite ores were mixed with one-fifth of their weight of charcoal, coke, or other carbonaceous matter, and heated to bright redness in a clay retort, or other suitable vessel, until the ore was converted to the metallic state. When the reduction was complete, the spongy iron (without previous cooling, as in Chenot's plan,) was transferred directly to a puddling-furnace, where it was brought at once to a welding heat, made into balls, and then wrought into blooms in the usual manner. This process was tried on a pretty large scale near Liverpool, in 1845-46, and although iron was regularly made by it for some time, and to the amount of 1000 tons, the process was not found to be commercially profitable, and was abandoned.

Clay's method

The process of Renton, patented in the United States in 1851, was very similar in principle and mode of working to that of Clay. The mixture of ore and coal was introduced into a vertical muffle or retort, which was inclosed in the flue or chimney of a furnace, not unlike an ordinary puddling-furnace. The contents of the muffle, being sufficiently heated, were reduced to the metallic state, and, from time to time, discharged from

Renton's pro-
cess.

Harvey's process.

the bottom, into the furnace, where the spongy iron was exposed to a welding heat, and wrought into blooms. This process, after having been essayed on an industrial scale at Cincinnati, and at Newark in New Jersey, was abandoned. A similar fate attended the trials, on a large scale, of Harvey's patented process, at Mott Haven, near New York, about the same time. In this, the coarsely powdered ore, mixed with charcoal, was placed on inclined trays or shelves of steatite, in a heated chamber connected with a welding or balling-furnace. The flame from a fire below was made to pass through the chamber, and the ore, being at length reduced to the metallic state, was transferred to the hearth below, and there converted into blooms. For a farther description of these various processes, and the similar plan of Yates, the reader is referred to Percy's *Metallurgy*, pp. 330-348.

Gurlt's patent.

Chenot's plan of reducing the ore by a current of carbonic-oxyd gas, was adopted by Gurlt, who used the direct mode of heating, already noticed. The gases from the generators charged with fuel, were led through flues, into the vertical reducing-chamber, a blast of air being at the same time introduced into the flues, in sufficient quantities to keep up the combustion of the gases. By this means, according to the specification, "there passes into the shaft a mixture of flame and carbonizing and reducing gases, by which the iron ore is heated" and carbonized. According to Gurlt's patent-specification, (No. 1679, London, July 16, 1856,) by continuing, for a sufficiently long time, the action of the gases, the resulting iron sponge may be more or less carbonized, so as to yield, by subsequent fusion, either cast iron or steel. These partially carbonized products he proposed to melt in a reverberatory gas-furnace, the blast of air into which is to be "so regulated that it exactly burns the gas produced in the generators," and that neither unburned gases nor unconsumed air escape; the object being to obtain a neutral flame, which should not alter the sponge upon the hearth. In this way carbonized sponges from rich ores, are said to have been successfully converted into cast iron in Spain.

Gurlt's ingenious specification thus involves the idea of first reducing the iron ore to a metallic sponge, and afterwards carbonizing this sponge, so that, by subsequent fusion, it may be converted into cast iron or steel. Although the conception of thus carbonizing the iron while in a spongy state, is probably novel, the use of carbonaceous gases or vapors for carbonizing iron, and converting it into steel, is not new, as may be seen from the patent for this purpose granted to Macintosh in 1825. The experiments of Percy upon iron wire have also shewn the rapid carbonizing effect of coal-gas and heavy oily vapors, like those of paraffine; (*Metallurgy*, pages 109 and 773) and, according to Marguerite, carbonic-oxyd gas, at

an elevated temperature, yields up a portion of its carbon to iron, which is thus converted into steel. Practical difficulties have hitherto prevented the application of hydro-carbon gases and vapors to the carbonizing of bar iron on a large scale.

With the results of Chenot, Gurlt, and Macintosh before us, we are prepared to understand the process of Dr. George Hand Smith, of Rochester, New York, which is just now attracting some attention in the United States, for the production of steel. The crushed and purified ore, or iron sand, mixed with a portion of pulverized charcoal, is heated in a kind of reverberatory furnace, with an arrangement which permits the vapor of petroleum or coal-tar to pass through the mass, thus aiding in the reduction, and finally carbonizing the resulting sponge, which is then transferred to a puddling-furnace, to be wrought into iron, or, if properly carbonized, into steel.

Before proceeding farther, mention should be made of some other methods which have been devised for the treatment of iron sands, and for their conversion into iron or steel. In 1851 a patent was granted to Stenson, for a process for working the iron sands of New Zealand, and similar ores from India. These were to be mixed with small portions of clay and lime, with or without the addition of charcoal; the mixture was ground in a pug-mill, with water, and formed into lumps, for subsequent treatment in the blast-furnace. In 1862, Moreau proposed to mix iron sands with iron filings or turnings, and then incorporate them with fuel, such as peat-coal or coke; the mixture being made into blocks, which were to be smelted in suitable furnaces. In 1866, Mr. James Hodges, who was not acquainted with the experiments of Moreau, moulded the iron sands of Moisie into blocks with peat, and by treating these, after drying, in a proper furnace, succeeded in converting the ore into malleable iron, at a single operation. (*Report of Geological Survey for 1866*, p. 291.)

Plans for working iron sands.

Messrs. Whelpley and Storer of Boston effect the reduction of the iron sand ore, or pulverized ores, on the hearth of a reverberatory furnace, which is heated, in part, by pulverized coal, borne by a blast of air over the fire of solid coal upon the grate. In this way the furnace-chamber is filled with a volume of burning coal-dust, which can, by regulating the supply of coal and of air, be made either oxydizing or reducing. The heated ore upon the furnace-hearth is thus reduced to the metallic state, balled and made into blooms, with, it is claimed, a great economy of fuel.

It has also lately been proposed to convert these sands into steel or cast iron, by melting with a sufficient admixture of charcoal in crucibles, or other closed vessels, heated from without. This is, in fact, nothing more than an extension of the dry method for assay of iron ores. A patent for making steel in this way, by treating rich ores, mixed with carbonaceous

Steel direct from
the ore.

matter, in air-tight melting-pots, was granted to Lucas, in 1791, and a similar claim was made by David Mushet, in 1800; while, according to Percy, "experiments in the direct production of cast steel from iron ores, in crucibles, were made by Riley, at Dowlais, a few years since, and although excellent steel was occasionally produced, it was not found possible to ensure uniform results." (*Metallurgy*, p. 765.)

Ponsard's
results.

More recently, Ponsard has brought forward a similar process, the results of which were communicated to the French Academy of Sciences, July 19, 1869. This arrangement consisted of a number of fire-proof crucibles, about eight inches in diameter and forty inches high, which were placed in a reverberatory gas-furnace, the mouths of the crucibles being fitted into openings in the furnace-roof, for convenience of charging. The lower part of the crucible is perforated, and rests on the sole of the furnace, which is furnished with gutters leading to a depression or basin in the middle of the furnace-hearth. The crucibles are charged with the ores, mixed with proper fluxes, and about twelve per cent. of carbon, sufficient to effect the reduction and carburization of the iron, which, under the influence of a very intense heat, melts, and, running through the holes in the bottom of the crucible, collects in the basin in the middle of the furnace. According to Ponsard, a ton of coal is consumed for each ton of iron produced, so that the process cannot be recommended for its economy of fuel. He, however, claims as a great merit of this process, the complete separation of the fuel from the carbon required for the reduction of the ore, so that for the furnace, inferior kinds of combustibles, which, if brought directly in contact with the ore, would injure the quality of the metal, may be used with safety and advantage.

Johnson's
patent.

The process patented by Johnson, Jan. 22, 1868, as described in the *Practical Mechanics' Journal* for June, 1869, (quoted by Osborn in his *Metallurgy of Iron and Steel*, page 868) is, however, exactly similar, in all its details, to that of Ponsard, which was first announced as a novelty to the French Academy, July 19, 1869, eighteen months later. In a specifica-

Larue's patent.

tion dated at Quebec, July 16, 1869, Dr. Larue claimed, and subsequently received letters-patent for Canada, for a process similar in design to that of Johnson, of which he was ignorant. Although there were differences in detail, the avowed object in both plans was to separate the ore, with the carbon required for its reduction, from the fuel, (which might, consequently, be of an inferior quality,) and to permit of a continuous charging and discharging of the crucible. The difficulty of constructing sufficiently refractory crucibles for the intense temperature, and the small yield to be expected from such a process, would perhaps prevent it from ever being used for the manufacture of cast iron. Dr. Larue, however, anticipated its application to the production, not of cast-iron, but of cast-steel, which

would require a very nice adjustment of the proportions of carbon to secure a uniform quality in the product; as in the ancient processes of Lucas and Mushet, and the more recent experiments of Riley, mentioned by Percy, and referred to above.

Two processes for the production of steel are those which depend, respectively, on the combination of cast iron in proper proportions with malleable iron or iron sponge, and with oxyds of iron. In the specification of a patent granted in 1839, Heath claimed the production of steel by melting with cast-iron, either wrought iron, or oxyds of iron or manganese. In a second patent, granted to him in 1845, he described an arrangement by which the cast-iron was kept in a molten condition, in a gas-furnace, while pure iron in scraps, or in sponge, obtained by reducing oxyd of iron, as in Chenot's and Clay's method, was added from time to time; until, by trial, the proper quality of metal had been obtained, after which the liquid steel was run into ingots. Other processes, based on the reactions embodied in Heath's first patent, are those of Uchatius, (patented in 1855,) who melts granulated cast iron in crucibles, with a certain proportion of pure oxyd of iron, and thus obtains a fine quality of steel, (a process already specified in Wood's patent, in 1761); and that of Brown, (patented in 1856) who, to produce steel, melts, in crucibles, mixtures of pig iron and clipped bar iron. This method is practised to some extent in Sweden, where it is known as the Obersteiner process.

In the process of Obuchow, which appears to be successfully used in Russia, fine pig-iron is melted, and run into a large crucible, previously heated to whiteness, and holding magnetic iron ore, alone, or with titanio iron sand and iron and steel scraps. The crucible is then heated till the contents are perfectly fluid, some nitre and arsenious acid are added, and the steel run into ingots. By a somewhat similar process to this, Ellershausen attempted to produce steel, by pouring molten cast-iron upon previously oxydized sheet-iron, heated to redness, and placed in a heated vessel. The oxyd dissolved in the molten iron with violent chemical action, decarbonizing it, and producing a kind of steel; but it would probably be difficult to effect a thorough conversion of the iron without keeping up the heat from without; which was not done in Mr. Ellershausen's first experiments, made in Montreal, in the spring of 1868.

The above processes, however, involve the use of crucibles, and it had become a great desideratum to produce cast steel upon the open hearth. This was the aim of Heath, in his process described above; but the difficulties in producing and controlling a heat sufficient for the purpose, were so great as to render the efforts in this direction but partially successful, until the regenerative gas-furnace of Siemens placed in the hands of metallurgists the means of fusing large bodies of steel on the hearth of a

Martin's steel process.

reverberatory. Provided with this, the Messrs. Martin, of Sireuil in France, have succeeded in producing cast steel, in charges of three and four tons at a time, by melting down wrought iron in a bath of cast iron, by what is now known as the Siemens-Martin process. The products thus obtained, attracted much attention at the Paris Exhibition, in 1867, and the process has since been widely adopted in Europe and in the United States; where it was first introduced by Messrs. Cooper, Hewitt & Co., and is now in successful operation at their works at Trenton, New Jersey.

Its operation.

Beginning with a bath of six hundred weight of pig iron on the hearth, malleable iron, as puddle-bars, for instance, is added, previously heated to whiteness, and rapidly dissolves in the molten cast iron, until, at the end of about four hours, the charge amounts to three tons, and will be found to consist of a soft, nearly decarbonized metal. It is then recarbonized by the addition of from five to eight per cent. of spiegeleisen (manganesian cast iron), as in the Bessemer process, and run in moulds. The bath of molten metal, during the process, is protected by a covering of fused slag or cinder.

The furnace-bottom for this process is made up of a silicious sand, which must not be quite pure, but contain some alumina or other bases, so that, under the influence of the high temperature, it may harden, without melting, forming an impervious crust, which will resist, for a considerable time, the action of the molten steel. The upper part of the furnace is built of Dinas fire-brick. Attempts have been made to use an admixture of oxyd of iron with the pig metal, in this process; but it is found that the corrosive action of the oxyd, at a high temperature, upon the furnace-bed is such as to preclude its employment. The entire cost of a furnace with a capacity of producing three tons of cast steel, with gas-producers, generators, and all the apparatus for moving the ingot-moulds, is, in England, about £500 sterling.

Bessemer's process.

This process, it is true, cannot compete with the Bessemer or pneumatic method for the cheap production of cast steel in large quantities; but while the latter is applicable only to certain fine kinds of cast iron, comparatively free from phosphorus and sulphur, the process in the open hearth permits the employment of other qualities of iron. These, in being reduced, by puddling or otherwise, to the condition of malleable iron, are deprived of the impurities prejudicial to steel, before being added to the iron bath. While, therefore, the Bessemer process will probably remain without a rival for the treatment of the purer cast-irons, the production of steel by the open hearth will perhaps become even more important, because of wider application. The Heaton process, for which so much was claimed as a method for the production of steel from impure cast iron, by the action of nitrate of soda, appears, from the late careful studies of

Heaton process.

Gruner, destined to become subsidiary to the production of steel in the open furnace. Gruner concludes that it "can never, from any point of view, become a substitute for the Bessemer and Martin processes. These produce ingots of steel, or homogeneous iron, from pure brands. The Heaton process deals with impure brands, and seeks to convert them into a refined metal, more or less purified, the treatment of which has to be finished in a Siemens furnace." He further declares that the only advantageous way of treating the products of the action of nitrate of soda on cast iron, is to submit them to the Siemens-Martin process. (*Annales des Mines* for 1869, fifth part.)

Mr. Bessemer has very recently made experiments upon the working of his process, under pressure, by which he obtains such an elevation of temperature, as, it is expected, will enable him to introduce malleable iron into his converters, and thus effect in them what Martin does upon the open hearth. In the mean time Siemens has, by the aid of his furnace, been able to carry out a part of the original plan of Heath, who, in 1845, proposed to reduce iron ores, by heating them, in small fragments, with charcoal, in a close vessel, as in the methods of Chenot and Clay, and to add the resulting spongy iron to the bath of molten cast iron. The reduction is, by Siemens, effected by a plan which combines the indirect and direct methods of Chenot.

Siemens's direct process.

Above the furnace, and immediately over the bath of molten cast iron, which occupies the hearth, are two large tubes of refractory clay, enclosed in an outer casing, through which the flame from the furnace passes, and allows these tubes, or reduction-chambers, to be heated, with their contents, to redness. They are charged from the top with finely broken rich ore, through which a current of previously washed and purified carbonic oxyd gas, from the common gas-generator of the furnace, is forced, and reduces the ignited ore to the condition of a metallic sponge of pure iron; this, descending, is at once dissolved in the molten cast-iron bath, and effects its conversion to steel, precisely as in Martin's plan, where solid malleable iron is made use of. In certain cases, as with very finely divided ores, the reduction is effected by an admixture of about ten per cent. of charcoal, or other carbonaceous matter.

Siemens has already manufactured excellent cast steel by this method, and there is no doubt that, in the case where pure oxyds, free from sulphur and phosphorus, can be obtained, the mode of directly producing steel with spongy iron may be advantageously employed.

A simple and ingenious process, based, like that of Siemens, on the original suggestion of Heath, has recently been devised and patented by Mr. Robert G. Leckie of Montreal. Having found that when finely-divided iron ore, as magnetic iron-sand, was made into lumps with peat,

Leckie's patent

coal, or other carbonaceous matter, not in excess, and exposed to redness, out of a current of air, there results a nearly pure spongy metallic iron, he proposes to obtain iron in this way, and add it to the bath of molten cast iron, in a reverberatory gas-furnace. The ore, agglomerated with the reducing material, is to be placed in one or more large chambers or ovens, in the rear of the hearth, and, when sufficiently heated to effect its reduction, is to be added to the bath of molten iron. He expects soon to test, on a working scale, this mode of making cast steel in the open hearth, to which the purified magnetic iron sands of Canada, from their freedom from sulphur and phosphorus, would seem to be peculiarly well adapted.

It is one of the great advantages of the Siemens furnace, that by a judicious regulation of the supply of air, and by proportioning it to the gaseous fuel, it is possible to obtain, at will, either an oxydising, a reducing, or a neutral flame; a point of much importance in the fusion of metals in the open hearth, which was already indicated in Gurlt's specification, as explained on page 46.

Siemens's
regenerative
furnace.

The employment of gaseous combustibles has been greatly extended since the successful use of the regenerative principle by Siemens. This consists in allowing the heated gases, after combustion in the furnace-chamber, to pass out, downwards, through two chambers packed with fire-bricks, so arranged as to allow a free passage of air between them, to which they impart their heat; the waste gases passing off into the stack at a temperature seldom above 300° Fahrenheit. After an interval of from half-an-hour to an hour, the current is changed, and the gases are led off through another pair of regenerators; while those which had been heated by the escaping gases are now used to conduct the air and gas for keeping up the combustion; these passing in through the heated regenerators, have their temperature greatly raised before entering the combustion-chamber. By alternately making each pair of regenerators the channels for the passage of the gases to be burned, and for the waste products of combustion, a very intense temperature is maintained in the chamber, with very little loss of heat.

Burning wet
fuel.

Coal and dry wood have generally been used in the gas-generators, where, by a partial combustion, the solid fuel is converted into combustible gases. With wet fuel, a large amount of steam becomes mingled with the gases, where its presence is very objectionable. This difficulty has, however, been entirely obviated by a system lately devised in Sweden, which may become of great advantage to Canada. I have therefore thought it best to copy from Mr. Abram Hewitt's Report on the Production of Iron and Steel at the Paris Exhibition of 1867, the following account of this valuable invention. This report, published by the United-States Government, contains excellent drawings of the furnace:

"The furnace devised by F. Lundin, of Carlstadt and Munkfors, is designed for the consumption of turf and peat, without drying, and of wet saw-dust or other moist fuel; an invention deemed so valuable that the association of Swedish iron-masters have rewarded Lundin by a gift of \$10,000, which, in Sweden, is a very considerable sum. In this furnace, the fuel is fed by a hopper, into a reservoir resting upon an inclined grate, supplied from below with air from a blower. The products of the combustion, thus maintained, pass through a condenser, where all the moisture in the gas is condensed. The gas then passes to the heating-furnace, which is furnished with Siemens's regenerators."

Lundin's furnace.

It is found easy to use fuel holding as much as forty-five per cent. of water. The gas, as it issues from the producer charged with such wet fuel, contains one fourth its weight of watery vapor. It passes at once into a chamber in which, from perforated pipes, small streams of cold water are discharged, crossing each other in various directions, and filling the chamber. By this, the gas is greatly cooled, and the acid and tarry matters present, with much of the steam, are condensed. It then passes through a second chamber, filled with wrought-iron bars, arranged like the bricks in the heat-regenerators, and kept cold by a stream of water trickling over them. The gas, which at the time of its escape from the producer, was heated to the melting point of lead, is thus cooled down until it retains only four per cent. of watery vapor.

"The expense of building a full-sized furnace, in Sweden, is about \$2500 in currency, and it is estimated that such a furnace will utilize 1700 tons of fuel in a year, at a saving proportioned to the cost of other fuel in the particular locality where it is employed. In Sweden, it is estimated that the annual saving, resulting not merely from the fuel, but from the repairs of the furnace, and the increased temperature, amounts to over \$5000 per annum, on the product of each furnace. * * * * * The gas produced by seasoned wood contains more water than that which proceeds from the Lundin condenser. The duration of the furnace is simply surprising, and is to be attributed, probably, to the fact that there is no cinder. In eight weeks, the thickness of the roof, four inches, was only diminished from $\frac{1}{2}$ to $\frac{1}{8}$ inch, and the side-walls were entirely uninjured. So wonderful is the success of this system of condensation, in connection with the Siemens regenerators, that, in Sweden, and, in fact, everywhere where moist fuel is employed, the Lundin furnace will supersede every other. Its great merit is, that it is available for any kind of fuel whatever. In the United States it is believed that this arrangement might be employed advantageously for washing the gas obtained from mineral coal; but its chief merit consists in the fact that in mineral regions, far removed from the coal fields, it is possible to establish iron,

works, using saw-dust or peat with entire success and great economy. In the lumber regions of Lake Superior it will be found to have a special value, because there is an abundant supply of pig-iron, accessible to the saw-mills on Green Bay and in Michigan, producing enormous quantities of saw-dust, slabs, and waste timber."

By the aid of the Lundin furnace, combined with the regenerators of Siemens, Rinman has succeeded in producing steel by the Martin process, using only pine saw-dust for fuel. When such results can be obtained with saw-dust, or with ordinary peat, the want of mineral coal need no longer be an obstacle to the development of the metallurgical industry of this country.

Boëtius's furnace.

The gas-furnace of Boëtius, which is now used for zinc-smelting, and in many glass-works, in France, is simpler and less expensive than that of Siemens. It does not make use of the regenerative principle, and hence the waste heat can be employed in boilers or for other purposes. In this furnace, however, there being no condenser as in the Lundin system, only dry fuel can be made use of. The air which serves to burn the combustible gases in the furnace-chamber, is heated by passing between the walls of the generator and an outer casing, these walls being made very thin, and supported at intervals, by bricks, which are built both into them and their envelope. This furnace does not enable us to obtain a heat sufficient for the production of cast steel, but is well adapted for puddling and reheating iron, as well as for zinc and glass-works, and is said to economize from 30 to 33 per cent. of the fuel. This description is taken from a paper by Gruner, professor of metallurgy at the Ecole des Mines of France, which appears, with working-drawings, in the *Annales des Mines* for 1869, fifth part. The same paper contains, also, descriptions, with drawings, of the Siemens-Martin steel process, besides an account of Ponsard's experiments, and of the Ellershausen process.

THE ELLERSHAUSEN PROCESS FOR MALLEABLE IRON.

The removal from cast iron of its carbon and silicon, and its conversion into malleable iron, is chiefly effected in two ways: of these the first consists in melting down the pig metal, before the blast, in an open fire known as a hearth-finery or bloomery, somewhat resembling the bloomery hearth used for the direct process of reduction in the United States. In the second method, the metal is melted and decarbonized in reverberatories, known as puddling-furnaces. In the puddling process the carbon of the iron is removed, partly by the oxygen of the air, and partly by that of the oxyd of iron, which, in the form of iron ore, is used for lining, the sides

of the furnace, or fettling, as it is called, for which purpose large quantities of magnetic and hematite ores are consumed.

In both of these processes the cast iron is melted, but there are two methods, which have long been known, in which the decarbonization of cast iron, and its conversion into malleable iron, are effected without fusion. In one of these, small objects of cast iron are imbedded in pulverized hematite ore, in carefully closed crucibles, and are then exposed for three or four days to a red heat; when, if the size of the castings is not too great, they are found to be decarbonized, and changed, throughout, into soft malleable iron. In this way are prepared the so-called malleable castings. Malleable castings. Very similar to this, in principle is, a process practiced in Wales some half a century or more since, and described by Percy, after Mushet (*Metallurgy*, p. 803). Granulated or shotted cast iron was mixed with a certain proportion of bloomary cinder, rich in oxyd of iron, and the mixture exposed for some hours, in covered crucibles, to a red heat. At the end of this time it was found that the grains of iron were decarbonized, and capable of being welded together; having been, in fact, converted into malleable iron by the action of the iron-oxyd. Old Welsh process.

By another process, the use of the oxyd of iron is dispensed with, and the iron is kept at a red heat, in contact with the air. In Tunner's method, Tunner's method. plates of cast iron, from one-half to three-fourths of an inch thick, are packed in boxes of quartz sand, so arranged as to permit the passage of air, and exposed to a glowing red heat for several weeks; at the end of which time the metal is found to be decarbonized, and converted into malleable iron. The impurities which form fusible slags, appear, in these methods of producing malleable iron, to be separated in a liquid form; sweating out, as it were, from the pores of the iron.

With these facts in mind, we are prepared to understand the results obtained by Mr. Ellershausen, which have given rise to the process bearing his name. In 1868, while making experiments on the production of steel, he endeavoured to incorporate coarsely pulverized oxyd of iron with molten pig metal, with the intention of subsequently melting down the mixture, and thus obtaining cast steel, by a process essentially the same with that of Wood and Uchatius (page 298). Ellershausen's discovery.

He found however, that the composite ingots of ore and pig metal, when heated on the hearth of a reverberatory furnace, did not fuse, but that the metal was rapidly decarbonized, and, with the separation of a considerable amount of liquid slag, converted with malleable iron, which could be taken at once to the squeezer, and rolled into bars of a quality superior to those produced by the method of puddling.

It might at first appear that, as in the production of malleable castings, the mingled oxyd of iron was the sole agent in thus decarbonizing and

Theory of the
process.

effecting the conversion of the metal, but subsequent experiments have shown that by reducing the proportion of ore much below that required, by theory, to effect the change; and even by replacing a portion of the ore by powdered charcoal, whose effect would seem to be the reverse of oxydizing and decarbonizing, as good results were obtained as before. In the pig-bloom, as the aggregate of pig metal and ore is termed, the iron is much subdivided, being partly in grains, and partly enveloping the granules of iron ore; the whole forming a somewhat porous aggregate, which is pervious to air, and thus offers a great extent of surface to its oxydizing action, as well as to the action of the intermingled oxyd of iron. Where an admixture of charcoal is used, it would soon be destroyed by combustion, and by the action of the accompanying iron-oxyd, and the mass rendered still more permeable to the air; so that the finely-divided white cast iron of the pig-bloom becomes rapidly decarbonized under the joint influences of the oxygen of the air and that of the ore. The ore, being in part reduced to the metallic state by the carbon and silicon of the cast iron, tends to make the loss of iron less than in the puddling process. In this view, the Ellershausen method unites the reactions of the process for malleable castings, and the Welsh process above described, where oxyds of iron are the decarbonizing agent, with that of Tunner, in which the decarbonization is effected by the oxygen of the air.

If we suppose the oxygen of the mingled iron ore to be the sole decarbonizing and purifying agent, the reaction would be as follows: the carbon of the pig iron, with the oxyd of iron, would give rise to metallic iron and carbonic-oxyd gas; while the silicon, which the crude metal always contains, in variable quantities, would reduce another portion of the oxyd, liberating metallic iron, and forming silicic acid. This, in its turn, would unite with a portion of unreduced oxyd of iron, to form a fusible silicate or slag, of the composition already referred to on page 282.

If we take the magnetic oxyd of iron, the reaction with carbon would be represented by



while with silicon we should have



The above equations lead to the following results for each unit of carbon and silicon in the pig iron:

1 carbon requires 4.83 magnetic oxyd, and gives iron 3.5, carbonic oxyd 2.33
1 silicon " 8.28 " " " " " 2.0, silicate of iron 7.28

Thus a pig iron holding, for example, 95.00 per cent. of iron, 4.00 per cent. of carbon, and 1.00 of silicon would require,

$$\begin{array}{rcl} 4 \times 4.83 & = & 19.32 \text{ of magnetic oxyd.} \\ 1 \times 8.28 & = & 8.28 \text{ " " " } \\ \hline 27.60 & & \text{" " " } \end{array}$$

and should yield 16 parts of reduced iron, and 7.28 of silicate of iron. In the case of some pig irons, which, in addition to 4.0 or 4.5 per cent. of carbon, contain 2.0, or even 2.5 per cent of silicon, the quantity of magnetic oxyd required, according to the above formulas, would be greatly increased. In the trials on a large scale, for the production of malleable iron by the Ellershausen method, at Pittsburg, Dr. Otto Wuth made careful analyses of the pig metal, and the resulting products, both iron and slag. From these analyses it appears that when 100 parts of a metal, holding over 1.0 per cent. of silicon and 4.2 per cent. of carbon, were mixed with from 28 to 30 parts of magnetic or hematitic iron ore, and treated as above described, the silicon, and nine-tenths of the carbon were removed, together with most of the sulphur and phosphorus. At the same time the resulting slag was much richer in iron than that obtained in puddling the same iron, or, indeed, than most slags from the puddling-furnace. It contained an amount of iron equal to not less than 64.7 per cent. of metal, and but 8.95 per cent. of silica, while the saturated silicate of iron, whose formula is given above, contains but 54.9 per cent. of iron, and 29.4 per cent of silicon. The highly basic slag from the Ellershausen process, as analyzed by Dr. Wuth, has thus a composition corresponding to a mixture of about 80 per cent. of a saturated silicate of protoxyd of iron, (with small portions of lime, magnesia, and alumina,) and 70 per cent. of magnetic oxyd of iron.

Wuth's analyses.

From this it appears that a large part of the ore added to the pig metal is not consumed, but passes off in the slag; and it would seem that, in this case, the principal action of the oxyd of iron had been the removal of the oxydized silicon. Each unit of silicon furnishes by its oxydation an amount of silica which requires at least four units of iron, in the state of protoxyd, for its conversion into the ordinary fusible silicate of iron. All of this oxyd of iron, in the ordinary puddling-process, except so far as furnished by the fettling, must be derived from the oxydation of the metal, and hence the great waste with highly siliciferous cast iron in the puddling-furnace. For such irons, therefore, the Ellershausen process would seem to be especially adapted.

Silicious iron.

Were the conversion of the iron to take place according to the formulas already given, solely by the action of the oxyd of iron on the carbon and silicon of the pig metal, 100 parts of this, having the composition above assigned, should yield theoretically, supposing no subsequent loss of iron by oxydation, or otherwise, 111 parts of pure iron; since to the 95 parts present in the pig metal, would be added 16 parts reduced from the oxyd, by the carbon and silicon. In practice, however, the gain is much less than this, leading to the conclusion that a part of the carbon is oxydized by atmospheric oxygen, while much of the added iron-oxyd must escape

Theory of the process.

unreduced, in the slags, as we have seen is really the case. According to Dr. Wuth, the result of the treatment of nearly 4000 tons of iron by the Ellershausen method, as above described, with about 28 per cent. of oxyd of iron, showed a gain of not quite 5 per cent. on the weight of the pig iron employed.

These conclusions are confirmed by recent results of the iron-works of Messrs. Burden, at Troy, New York, where the Ellershausen process has been found to give satisfactory results, with 15 per cent of magnetic iron ore, although the quality of the product was improved when 20 per cent. of ore was used.

Suggestions for
practice.

Analyses of the pig metal, the ore, and the products, in such trials will be most important as serving to shed farther light on this new process. Meanwhile the following suggestions with regard to it seem warranted by the facts before us. 1st. The ore used should be as free as possible from impurities. Silicious matters, by uniting directly with the oxyd of iron, occasion a large loss of ore; while lime, magnesia and alumina-compounds, not only increase of the bulk of slag, but render it pasty and difficult to be removed from the iron. 2nd. The ore should be finely divided, inasmuch as more surface will thus be presented to the iron. In the working of the process at Pittsburg, much of the ore added was in coarse grains, which escaping, dissolved in the slag, but otherwise unchanged, caused this to be, as we have seen, extremely rich in oxyd of iron. The coarse grains, it may be supposed, serve however to give to the aggregate that mechanical condition which is favorable to the proper working of the process, a result which would probably be equally well secured by the admixture of a portion of charcoal; an experiment, which I am informed, has already been successfully tried at Pittsburg. The use of a greatly reduced proportion of finely divided and very pure ore, together with a portion of coarsely ground charcoal, would therefore seem to promise the best and most economical results with the Ellershausen process. Rich hematite, free from silica, or magnetite, previously calcined, and if necessary, purified, after crushing, by the aid of a magnetic machine, should be tried. The magnetic portion of the fine iron sands from the lower St. Lawrence would probably yield excellent results in this process. Some experiments made at Pittsburg, in which the purified iron-sand was used in place of the ordinary ores, are said to have given a superior quality of iron. The ores used in the trials which gave the products studied by Dr. Wuth, were, however, the magnetite of Lake Champlain, with some hematite from Missouri.

Choice of ores.

From what has been said, it will be evident that the supply of air in the furnace should be as abundant as in the process of puddling, and that a reducing or feebly oxydizing atmosphere therein, would either greatly modify the conditions of the Ellershausen process, or lead to failure.

The novel invention of Ellershausen, on which his patent is based, is the mixing of crushed or pulverized ore with the molten metal, as it flows from the blast-furnace or cupola, thus forming masses of conglomerate, which are subsequently exposed to heat in a reverberatory furnace. The mingling of the two, was, in the first experiments, effected by pouring them simultaneously into an ingot-mould, while the mixture was stirred with a wooden pole. This method, however, is replaced by an ingenious arrangement of a large horizontal turning-table, around the periphery of which is a trough, divided, by partitions, into a series of compartments, into which the ore and the liquid metal are simultaneously discharged. The table being made to revolve, each compartment receives, in succession, a thin layer of mingled ore and metal, more or less intimately mixed, and the process is continued until the moulds are filled; when the consolidated masses, composed of successive layers, not over four tenths of an inch in thickness, are removed, and are ready to be placed in a common puddling or other reverberatory furnace. Here, at a white heat, if the proper conditions have been observed, the conglomerate softens, without melting, the slag begins to flow out, and the iron is soon ready for the operations of squeezing and rolling.

Turning table.

It is claimed for this process for the production of malleable iron, that it requires much less time than puddling; the average time required for the treatment, in an ordinary single puddling-furnace, of a charge of 800 pounds of the conglomerate, producing about 600 pounds of muck-bar, not being over an hour and a quarter. The consumption of coal is reduced about one-half, and the ordinary labor of the puddler is done away with, the masses in the furnace requiring but little manipulation. The rapid wearing of the furnace-bottom, which in puddling, causes such a loss of time, is also obviated. In addition to these advantages, which in Pittsburg, it is claimed, effect a saving of eight or ten dollars a ton, it is found that the iron produced in this way is superior in quality to that obtained from the same pig metal by the process of puddling. This superiority is apparently explained by the fact, established by Dr. Wuth's analyses, that the sulphur from the pig metal is more completely eliminated by the Ellershausen process than by puddling. The analyses, with a summary of the report will be found in the *Chemical News*, American edition, in the supplement for October, 1869; and with Dr. Wuth's report, in full, in Osborn's *Metallurgy of Iron*, page 565.

Advantages of the process.

The Ellershausen process is now regularly worked at Pittsburg, by Messrs. Shoenberger and Co., and in one or the other places in the United States; and in the opinion of some who are best qualified to judge, is destined to general adoption. Its introduction has been retarded by various causes, among which are the jealousies of puddlers, and, in some cases, by partial failures, the probable causes of which have been pointed out in the preceding pages.

Granulated
iron.

Numerous patent-claims, from that of John Wood, in 1761, down to the present time, have been based upon the use of granulated or pulverized cast iron for the production of steel or malleable iron. The iron is granulated by beating in large mortars, when heated nearly to its melting point, or by causing it to fall into water, through the air, or upon a rapidly-revolving disk, from which it is thrown off by centrifugal force. The grains of iron, more or less oxydized at the surface, are directed to be conveyed to a furnace, and there formed into lumps for the rolls or hammer; or else mixed with oxyd of iron, and exposed to heat in a furnace, (or in close vessels) whereby a malleable iron, fit for the manufacture of steel, is obtained. See, among others the specification of Bousfield, in 1857, No. 3082, and that of Morgans, in 1865, No. 806, of the British Patent Office. In so far as these propose to work in the open furnace, they differ from the old method of Wood, and the Welsh process, already described, page 299, and approach to the conditions attained in the Ellershausen process. Excellent results have recently been obtained by Mr. Hewitt at Ringwood, New Jersey, by mixing the granulated cast iron, with iron ore in grains, and exposing the mixture to heat on the hearth of a reverberatory; when decarbonization, and conversion to malleable iron takes place, as in Ellershausen's method, without fusion.

It had been proposed, as mentioned on page 211, to give in a third part of this report, some chemical and mineralogical notes with regard to the gold, silver, and bismuth ores of Hastings county, Ontario. The results of my analyses, so far as they are of economic interest, and the principal facts relating to the mode of occurrence of these ores, have, however, been furnished to Mr. Vennor, and are given on pages 170-171 of this volume. The report has, moreover, exceeded the limits originally proposed for it, and it has therefore been thought best to defer the publication of many interesting chemical and mineralogical details to another occasion.

REPORT

BY

MR. JAMES RICHARDSON,

ADDRESSED TO

ALFRED R. C. SELWYN, Esq.,

DIRECTOR OF THE GEOLOGICAL SURVEY OF CANADA.

SIR,—In the month of May last I was instructed by Sir W. E. I to make a geological examination of the north shore of the lower St. Lawrence from the River Saguenay to the Bay of Seven Islands, a distance about 220 miles; I was also directed to ascend one or more of the principal rivers on the coast. Those selected were the Manicouagan and the Saguenay; the former was surveyed for about forty miles up, while the latter, which had already been surveyed by Admiral Bayfield, was ascended a distance of thirty miles. A map of the area examined has been constructed on a scale of four miles to one inch, on which the geological facts and other characteristics of the country are laid down.

Having completed my survey of the north shore, about the middle of September, I returned to Montreal, and was then ordered to proceed to Trois Pistoles, on the south shore of the St. Lawrence, and continue there the north-eastward my work of 1868, which had terminated at that point. It was resumed and carried along the coast as far as Father Point, a distance of about forty miles. Examinations were also made along several transverse lines of from four to ten miles, in a south-east direction; more are, however, wanting before my results in this district can be given in complete form.

On the north shore the geological formations of the area examined

1. Laurentian gneiss.
2. Labradorite rocks.

The Laurentian gneiss sometimes has little appearance of stratification; the strike is generally nearly north and south, with dips often approaching the vertical. The strata are all more or less broken, contorted and faulted.

The labradorite rocks rest unconformably on the Laurentian; they generally strike nearly east and west, and dip at comparatively moderate angles, with little or no appearance of contortion or disturbance.

The Laurentian rocks consist chiefly of coarser and finer reddish and greyish gneiss, often syenitic, and marked by dark bands holding much hornblende or mica. A coarsely granitoid reddish syenitic gneiss was observed at the following localities, viz:—Ten miles up the Bersimis; on the Outarde River from the tide-way, for a distance of five miles; and on the coast a little east of the Papinachois.

Intrusive
diorites.

At Escoumains a fine white granitoid gneiss occurs, composed of pure white feldspar and quartz, with, rarely, small grains of black hornblende. In the neighbourhood of Point de Monte and Trinity Bay, considerable masses of a fine gray diorite, which appears to be intrusive, are found among the gneisses, and numerous dykes of black fine-grained trap are also met with in the vicinity.

Crystalline
limestone.

On the coast, two miles east of the Papinachois; on the north side of the Government Road, about a mile east of the Great Bergeron Cove; and about sixteen miles up the Manicouagan River, at the foot of the seventh portage, vitreous quartz rock occurs in masses of from 50 to 120 feet in thickness. Some of this rock is very pure, and might be used for glass-making; but much of it holds sparingly disseminated plates of flesh-red feldspar, and a pale green steatitic mineral. About twelve miles up the river last named, there occurs in the gneiss a bed, twelve feet thick, of coarsely crystalline limestone, gray, yellowish, and occasionally pinkish in colour, and holding grains of green pyroxene; this, with the exception of a thin seam of dolomite found at Lobster Bay, is the only Laurentian limestone observed during the season.

Labradorite
rocks.

The labradorite rocks along the coast examined offer many varieties in character and aspect, but are generally bluish or greenish in colour, much resembling those found to the north of Montreal; in one case beds were met with holding considerable quantities of red garnets in lumps up to half an inch in diameter. Some of the beds contain much black mica, and others nodules of a gray fibrous hornblende approaching actinolite; varieties of the labradorite rock were also met with holding hypersthene, and small masses or layers of magnetic iron ore.

The first locality to be noticed, where these rocks occur, is at the mouth of Pentecost River, and for about half a mile to the north-eastward. The rock is here banded with coarser and finer varieties, holding small lumps of red garnet, mica, actinolite and iron ore, which make its stratification very apparent; it dips with much regularity N. 23° E. < 30° to 40°, as may be seen for half a mile along the shore; which here trends nearly north and south, in a succession of low bluffs, seldom above thirty feet in height.

In Lobster Bay, half a mile further to the eastward, after an interval of concealment, the reddish quartzose granitoid rock of the Laurentian is again met with, offering no evidence of stratification; and in one place is seen to be distinctly overlaid by a patch, only a few yards square, of labradorite-rock, shewing considerable varieties in character, and clearly stratified, with a strike N. 58° E. Labradorites.

Labradorites are the only rocks seen from the May Islands to Point St. Margaret, and also at the falls of the river of that name, the interval being concealed by sand. Rocks of the same series were observed by Dr. Hunt at the head of the Bay of Seven Islands, enclosing a large mass of titanite iron ore, and they form also the great southern promontory of the bay, where the rock is generally more or less coarse-grained, greenish-blue in colour, and holds hypersthene and titanite iron ore. The dip of the beds of labradorite-rock, as seen here along a distance of three or four miles, is generally uniform to the north, at angles of from 10° to 20° . At the falls of the St. Margaret the dip is N. 28° E. $< 22^{\circ}$, while at Point St. Margaret it is S. 32° E. $< 82^{\circ}$.

Both the Laurentian gneiss and the labradorites are cut by granitic veins, sometimes of considerable width, made up of large crystalline masses of deep red orthoclase, often with a pale green feldspar, probably oligoclase, black crystalline hornblende, vitreous quartz, and sometimes crystalline masses of magnetic iron ore. Granite veins.

Besides the above crystalline rocks, a small patch of Silurian limestone occurs on the east side of Manowin, one of the group of the Seven Islands. The beds of this light-coloured fossiliferous Silurian limestone are seen to repose on reddish gneiss, and dip northward at an angle of from 2° to 6° ; The fossils, according to Mr. Billings, shew it to belong to the Trenton group; it has been quarried for use at the Moisie iron-works, near by. Silurian limestone.

In addition to the economic materials already mentioned, the iron sands of this region, which have attracted considerable attention, may be noticed. The deposits of these sands at Moisie have been examined by Dr. Hunt, who has shewn that they belong to the stratified silicious sands of the district, which here overlie the old marine clays, at considerable heights above the present sea level. In many places I observed beds holding so much iron ore as to shew dark or nearly black layers among the gray and brown silicious sands. They were seen, of this character, at various places along the coast, at heights up to 100 and even 200 feet above tide-level; while on the Manicouagan River, twenty-four miles from its mouth, where it attains a height of 256 feet above the sea, the banks of sand exhibited the same dark-coloured bands of iron sand, from forty to fifty feet above the water. Iron sands.

On the coast between Portneuf and Sault au Cochon, and also between

Iron sands.

the River St. Margaret and the Bay of Seven Islands, hills of post-tertiary clays, containing marine fossils, and attaining heights of from 50 to 150 feet, are often seen to be capped with from forty to fifty feet of similar fine and coarse brown sand, banded with dark layers likewise charged with black iron ore.

The rich accumulations of ore which are seen along the beach appear, as Dr. Hunt has remarked, to result from a natural process of concentration by the action of the water upon these sands; they were observed in a great many places on the coast, about high-water mark, in strips from three to nine and twelve feet wide, and from two inches to two feet in thickness, often extending without interruption, for miles. It is said that the visible extent and the richness of these local deposits is somewhat affected by the varying action of the wind and water. The places at which I noticed these belts of iron sand along the portion of coast examined are as follows, viz:—

1. The vicinity of Tadousac, for a distance of three miles downwards.
2. From Jeremie to Bersimis, and thence to the Papinachois, a distance of twelve miles.
3. The peninsula at the mouths of the Outarde and Manicouagan rivers, for thirty miles.
4. From English Point to Pentecost River, for eight miles.
5. The coast on both sides of the St. Margaret River for ten miles; making in all sixty-six miles.

In all these places except the first named, near Tadousac, I think that the quantity of ore is such that it might be collected with profit, especially by the aid of proper concentrating machinery. Water-power, if needed, is accessible in several localities near the iron sands; among others, at the falls of the River Baude, on the coast, three miles below Tadousac; at the falls of the Papinachois, also on the coast; at those of the Outarde and Manicouagan, at the head of tide-water (respectively twelve and fifteen miles from the general trend of coast): at a fall in a stream, on the coast, half a mile north-east of Pentecost River; and at the falls of the St. Margaret, three miles from the coast.

The mouths of the Bersimis, Papinachois, Outarde, Manicouagan, Pentecost, and St. Margaret, all afford safe harbours, with sandy bottoms, which vessels drawing twelve feet of water may enter at high tide, although the access is somewhat difficult, on account of numerous sand-banks. In any of them a wharf extending from forty to fifty feet from the shore would be sufficient to reach the channel.

Geographical features.

The surface of the whole region examined, with the exceptions mentioned below, is broken and irregular. The hills of hard rock occasionally attain a height of upwards of 2,000 feet, besides which, there are hills of

stratified clays, capped by sand, often rising 200 feet or more ; and in one instance near Tadousac, 400 feet.

A very thin soil occasionally occurs on the rocky hills, but, generally over large tracts where fires have destroyed the vegetation, little remains but a bare surface of solid stone.

On the portion of the coast between the Saguenay and the Outarde, Forest trees where the soil permits, there is timber of fair size, consisting of yellow pine, spruce, balsam-fir, tamarack and white birch. Yellow pine was formerly cut on the Portneuf River, and considerable quantities still remain on the rivers Escoumains, Sault au Mouton, Sault au Cochon, Bersimis, and Papinachois. Pine logs, as I saw them at the mills, and in the forest, were from twelve to twenty inches in diameter. Beyond the river Outarde no yellow pine is met with, and from thence to the Seven Islands, the other trees are smaller, and the barren portions are more extended.

From Tadousac to the River Baude, a distance of about three miles along soil. the coast, there extends a belt, less than a mile in width, of yellowish-brown sand, mixed with thin layers of the iron sand already noticed. Following the river just named, for about two miles northwardly, the clays gradually come out from beneath the sand, and afford an excellent soil. The Hon. David E. Price, Senator, informed me that this kind of soil stretches northward towards the St. Margaret River, and is of considerable extent ; but it is not accessible for want of a road. On the Little Bergeron Cove and River, there is a strip of similar good soil, four or five miles long by about a mile wide, and on the Great Bergeron Cove, there are from 1,000 to 1,500 acres of excellent land, yielding good crops of vegetables, and all kinds of grain.

From the cove last mentioned, to the Escoumains, a plain extends from the shore to a bare ridge of reddish gneiss, from two to seven miles inland, and occupies an area of forty to fifty square miles. The soil of this plain is a coarse brown sand, with patches of moss, probably in depressions, and sustains a growth of blue-berry and other shrubs, with a few stunted spruces, balsam-firs and white birches. Some attempts have here been made at farming, but with very little success, except at a few spots on the coast, just to the west of Cape Bon Desir, where the clay, which underlies this sand, has been uncovered by land-slides.

From the village of Escoumains, at the mouth of the river of that name, to Mille Vaches Bay, a distance of about twenty miles, extends a belt of sand like that just described, and from one to two miles in breadth, with occasional protruding spurs of gneiss rock. Here, as before, the only successful attempts at cultivation are confined to spots where the underlying clay has been exposed by the cause above mentioned.

From Mille Vaches Bay to Sault au Cochon, a distance of twelve miles

a similar sand plain prevails along the coast, also extending about two miles inland. From the last mentioned point to the Portneuf River, cliffs of clay, capped by sand, rise boldly up from the shore to heights of from 100 to 200 feet. These cliffs, which have already been mentioned in speaking of the iron sands, have in their lower part from fifty to probably one hundred and fifty feet of fine blue clay, in which the fossil remains of the *Mallotus villus*, or capeling, and several species of recent marine shells, were found imbedded. The brown sand, often forty or fifty feet in thickness, which overlies these clays, presents alternate coarse and fine layers, and is banded with others holding black iron sand. Beyond Portneuf to Jeremie, a distance of about fourteen miles, the coast is rocky, and affords only a few isolated patches of sandy soil; but from Jeremie to Point St. Giles, at the mouth of the Manicouagan, a distance of nearly forty miles, there is a recurrence of the sandy plains, with occasional protruding masses of hard gneiss rock.

Along this coast considerable portions of land are covered with moss, as may be seen just to the east of the Indian Village and Hudson Bay Company's post at Bersimis. These sandy tracts include a part of the Bersimis Indian Reserve, together with the peninsula between the mouth of the Outarde and Manicouagan Rivers, and have an extent which may be approximately estimated at 200 square miles. In ascending the Bersimis River for about thirty miles, occasional patches of from 200 to 1,000 acres of sandy soil are met with, lying between rocky ridges.

In ascending the Manicouagan River from a point twenty-four miles from its mouth, to the Forks, fourteen miles further, is a reach of deep water, with a gentle current, between banks from ten to fifty feet high, composed of brown sand, with layers holding the usual black iron ore. The river here, as already mentioned, is 256 feet above the sea, and the valley, which is about a mile in width, is walled in by ridges of gneiss rock, rising above it to heights estimated at from 300 to 1,500 feet, often bare of vegetation. This sandy valley supports in most places a stunted growth of spruce, balsam-fir and white birch, but at the Forks, and for about four miles below, the soil is a loam, and produces a growth chiefly of poplars and white birches, which attain a fair size; one of the latter, which I cut down, was eight inches in diameter at the base, and 102 feet high; its age, judging from the rings of growth, was between sixty and seventy years.

From Point St. Giles to the Godbout River, a distance of twenty-six miles, the coast is mostly rocky and barren, with the exception of about 600 acres of sandy soil at the mouth of the river, surrounded by rocky gneiss hills; thence to English Point, a distance of thirty-five miles, the country is still mostly barren and rocky. From English Point to Pentecost River, about eight miles, another belt of similar sandy soil occurs, with an average width of from one to two miles.

REPORT OF MR. JAMES RICHARDSON.

From Pentecost River to Point St. Margaret, twenty-four miles, and also to a few miles beyond the latter distance of thirty miles, a similar, sandy soil occupies an area of about 500 square miles. In the rear of the St. Margaret and the Moisie River, bare rocky hills of average height of nearly 1,000 feet.

In the interior, areas not observed, of the same kind with; but they are probably small in extent and Although these sandy soils are capable of being cultivated knowledge of their management is required to do so successfully.

I have the honour to be,

Sir,

Your most obedient servant

JAMES RICHARDSON

Montreal, 18th April 1870.

REPORT

BY

MR. ROBERT BELL, C.E., F.G.S.,

ADDRESSED TO

ALFRED R. C. SELWYN, Esq.,

DIRECTOR OF THE GEOLOGICAL SURVEY OF CANADA.

SIR,—I have to report that, in compliance with the instructions which I had the honor to receive from Sir W. E. Logan, I proceeded, in May last, to make a geological examination of the country lying on the north-western side of Lake Superior. Fort William was selected as my head-quarters for the season, from its being the most conveniently situated point for our explorations in the region around Thunder Bay, and from having a post-office, and frequent steamboat communication with the east, and because we could here find safe storage for our provisions and outfit. We were under many obligations to Mr. McIntyre, the gentleman in charge of the Hudson Bay Company's establishment at Fort William, for the accommodation of one of his storehouses, for advice and assistance in procuring proper guides, for the use of boats and canoes, for tracings of various maps in his possession, for much valuable information of all kinds, which his long experience in that region enabled him to give in regard to the country which we examined, and for his kindness and attention generally in promoting the objects of the expedition. We were also greatly indebted to the families of Mr. McIntyre, Mr. McVicar and Mr. McKellar for their kind hospitality whenever any of our party happened to be at Fort William. The officers and employes, generally, of the Hudson Bay Company aided us cheerfully whenever an opportunity occurred. Amongst those from whom we received information or assistance, I may mention Mr. Hopkins of Montreal, Mr. McKenzie of LaCloche, Mr. Bell of Michipicoten, Mr. Charles De La Ronde of Red Rock, Mr. Crawford of Nipigon House, Mr. Henry De La Ronde of Poplar Lodge, Mr. Whyte of Basswood Lake

Acknowledgement, of aid.

and Mr. Pether of Fort Frances. Before starting from Toronto, Mr. Andrew Russell, of the Crown Lands Department, very kindly furnished me with tracings of maps, and with extracts from reports relating to the country to be explored. I am indebted to Mr. Thomas Herrick, P.L.S., for his plan and field-notes of the survey which he made of the Nipigon River; to Messrs. Peter, John and Daniel McKellar for the results of their geological explorations in the country from Pigeon River to Black Bay, and back to a considerable distance beyond Dog Lake, and for numerous topographical features, including a plan of their survey of Current River; also to Mr. H. P. Savigny, P.L.S., of Toronto, Mr. Hugh Wilson, P.L.S., of Mount Forest, Mr. S. J. Dawson, C.E., Mr. W. B. Borron, Inspector of Mines at Fort William, Captain Symes of the steamer Algoma, and Chief Manitoussaise of Nipigon, for their kindness in aiding our exploration in various ways. I was assisted in the labors of the season by Messrs. P. McKellar of Fort William, P. B. Ball of Guelph, A. D. Blackader of Brantford, W. Notman of Hamilton, A. McKenzie of Clifton, W. W. Russell of Toronto, C. E. Dobbs of Kingston, and P. McLaren, B.A. of Lanark.

Assistants.

The first month was devoted to an examination of the coast from Prince's Bay to Fort William, the country between this section of the coast and the lower stretch of the Kaminitiquia River, the valley of this river, the country between Thunder Bay and Dog Lake, and the shores of Thunder Bay. As required by my instructions, I paid particular attention to the geology of the silver deposits of this region, which promise to be of importance.

Lake Nipigon.

In addition to the district first referred to, I was directed to make an exploration, or if possible, a survey of Lake Nipigon. In tracing the run of the rocks eastward and northward from Thunder Bay, I found that many advantages would be gained by proceeding to this lake as early in the season as possible. By doing so, I hoped to have enough of the summer left to make considerable topographical surveys in that region, which would serve as a correct basis for laying down our geological work. In June last, I had the honor to communicate to Sir William Logan, by letter from Fort William, my reasons for believing that the Huronian and Upper Copper-bearing rocks would be found to occur around Lake Nipigon. In extending our explorations in the region assigned to me, from the Thunder Bay side only, we were constantly in the dark as to the general nature of the geology of the country ahead of us. Whereas, by mapping that of the Nipigon district, we should have determined the geology of the two sides, and thus rendered it much easier to work out that of the intervening area. Having ascertained from the officers of the Hudson Bay Company and the Indians, that Lake Nipigon was much larger than

commonly supposed, and considering how desirable it would be, for our purposes, to have a complete traverse of its shores, I engaged Mr. Peter McKellar of Fort William, who is both a surveyor and a geologist, to assist me in the undertaking; and the result proved that I was very fortunate in doing so.

Before starting from Fort William, I had the honor to receive the additional instructions, which had been forwarded to me by Sir W. E. Logan, at the suggestion of the Honorable Mr. McDougall, then Minister of Public Works. These directed me to take levels, and to make all possible observations with a view to ascertaining the practicability or otherwise of a railway to the North-west Territories through the country which we might examine. I am happy to have been able to report that our explorations have enabled me to trace a route which appears to be quite practicable for such a purpose, as far as we went, or through a distance of about one hundred miles in the proposed course, beginning at Lake Superior. In the following pages, I propose to add some details to those which were contained in the special report of 22nd February on this subject, which I had the honor of addressing to you. *

The Nipigon River having been carefully surveyed by Mr. Herrick, it Plan of Survey. only remained for us to make what geological observations we could, while ascending it. Having arrived at Lake Nipigon, I divided our party, and gave Mr. McKellar charge of one of the sections. Beginning on the south side of the lake, at the point where Mr. Herrick's line intersected the shore, Mr. McKellar proceeded to the right, or east side, while I took the west. At the end of about eight weeks, the two parties met at the northern extremity of the lake, having completed a survey of its shores, excepting the deepest parts of a few of the bays. We had also explored, and in some cases surveyed, the lower reaches of the principal rivers entering the lake, and determined the positions and forms of about 460 of the islands, lying within easy reach of the shore, and more roughly the positions and outlines of about 100, lying further off; while time did not permit of our ascertaining, personally, anything with regard to a considerable number in the centre of the lake. When on the south-west side, I made a journey of several days into the interior, following the lakes and streams, and making portages between them. In this excursion, I was guided by Chief Manitoussais's son, Tchiatang, a very intelligent Indian, whose services I had secured for the summer; and I had on this occasion, an opportunity of proving the accuracy of the sketch-maps of the region which he had previously made for me. This man had travelled a great deal in the Nipigon country, and beyond it. Having a very correct idea of distance, by using a compass, laid upon the paper, to guide him as

* Transmitted to the Honorable Secretary of State for the Provinces.

to direction, he prepared for me a number of sketch-plans, shewing the geography of the districts through which he had travelled, together with a great deal of other useful information. The country south of Gull Bay on Lake Nipigon, was explored by following the Kabitotiquia River and making a portage from it to Chief's Bay on the same lake.

Measurements.

Our surveys on either side of Lake Nipigon, which were effected mostly by triangulation, were carried on in two bark canoes. Distances were checked and details filled in by the Rochon micrometer. The angles were determined by the sextant and Troughton's repeating circle, the local magnetic variation being so great and so uncertain as to render the compass of little use on most parts of the lake-shore. A true meridian was occasionally laid down, by which to fix the directions of our lines; and latitudes were taken for the purpose of checking our measurements. The heights of some hills were ascertained by angles of elevation, or by means of two aneroid barometers, which were also used in determining the amount of fall in the rapids of the Nipigon River.

Black Sturgeon lake and river.

In returning from Lake Nipigon, Mr. McKellar made an actual survey of the west shore of Black Sturgeon Lake, and of the river of the same name, as far down as Nonwatan Lake, and an approximate one from that lake to its mouth; whilst I, returning by the same stream, made two traverses of the country lying between it and the Nipigon River. On my return to Lake Superior, a partial examination of the north-west shore of Black Bay was effected; some additional explorations were made on the north side of Thunder Bay, and along the Red River Road, as far as it had been opened, after which the work of the season was brought to a close, and the party returned home, all well.

Throughout the season, I worked upon the principle which we have always pursued upon the Geological Survey, in exploring or surveying in a new region, namely, that of following, as much as possible, the water-courses, instead of cutting "exploratory lines" in the woods. The following may be mentioned amongst the many advantages of this system: (1) We avoid the expense of cutting the lines, which would add but little to our knowledge of the natural features of the country, and would soon be obliterated. (2) The clear space afforded by the surface of the water serves better than an artificial opening in the woods for measurements by the micrometer, which may be made as accurately as by the chain. It also admits of triangulation, which is impossible in the forest. (3) A greater distance may be surveyed per day. (4) A smaller party can do the work. (5) The canoes or boats by which the survey is carried on, also serve to convey, at the same time, the supplies of the party, and allow of a considerable quantity being taken, thus enabling the work to go on continuously for a greater distance, or a longer time, without reference to the base of

operations, than where everything has to be carried on men's backs. (6) The river-beds and lake-shores afford many more exposures of the rocks than are to be met with in the woods, where they are covered by earth or moss. (7) The same measurements, which serve to determine correctly the distribution of the rock-formations, also enable us to lay down the topographical features of the country, and thus we obtain a knowledge of its geography simultaneously with that of its geology.

The principal results of the season's operations may be briefly summed up as follows:

Summary of
season's work.

1. The working out of the geology of the country around Thunder Bay, including an area of the Huronian system not previously recognized, and the addition of many new facts in regard to the mineral veins of this region.

2. A survey of Lake Nipigon and portions of several of the rivers flowing into it, and the obtaining of approximate levels along the Nipigon River, besides an examination of much of the country near Lake Nipigon.

3. Ascertaining the fact that a large area north of Lake Superior, including the Nipigon country, is occupied principally by the Upper Copper-bearing and Huronian rocks, instead of the Laurentian, as had been supposed, and that it therefore offers a greater probability of the discovery of valuable minerals, and besides, affords a much better country for colonization and for the construction of highways.

4. The discovery of an apparently easy route for a railway to the North-West Territories through the country explored, for a distance of about one hundred miles from the mouth of the Nipigon River on Lake Superior.

For the sake of convenience, the tracts examined will be described in the following separate sections as: 1. The Thunder Bay region, embracing the country from Pigeon River to Black Bay. 2. The valley of the Black Sturgeon River. 3. The Nipigon River. 4. Lake Nipigon and the surrounding country. These will be followed by sections on the economic minerals of the district examined, surface-geology, soil, timber, climate, the opening of the Nipigon country for colonization, the railway route, and other matters.

I have laid down our surveys of Lake Nipigon and the rivers entering it, and of Black Sturgeon Lake and River, together with Mr. Herrick's survey of the Nipigon River, and Admiral Bayfield's of a portion of Lake Superior, all in a connected form, on a scale of one inch to the mile, upon the large sheet accompanying this Report. It was satisfactory to find, on plotting the work, that the measurements of Mr. McKellar and myself, around the opposite sides of the lake, closed very well. The accompanying map of the whole country between Pigeon River and Nipigon Bay on Lake Superior, and northward to the waters flowing into the Albany River, on

Geological map

a scale of one inch to four miles, is based upon Mr. Robert Barlow's compilation of all the actual surveys which have, at any time, been made within that region, with the addition, by myself, of the other features, as nearly as they can be laid down, from all other sources available up to the present time. Upon this, I have represented the geology, as far as it has been determined by Sir W. E. Logan and Mr. Murray, and from the explorations of last year, with the addition of the information derived from Mr. McKellar and others already mentioned.

GEOLOGY.

The rocks of the country examined during the season belong to the Laurentian, Huronian and Upper Copper-bearing series. For the sake of facilitating my description of

THE UPPER COPPER-BEARING ROCKS,

Upper Copper-bearing rocks.

I will introduce the following list, which represents, in ascending order, the subdivisions of this series, as far as known, in the region under consideration. It is prepared from the descriptions by Sir W. E. Logan, in the *Geology of Canada*, and those by Mr. Thomas Macfarlane in the *Canadian Naturalist*, as well as from our own observations during the past season. As this district is, even yet, but imperfectly examined, some portions of the series may have been overlooked, and, therefore, this provisional arrangement of its members may require modification at some future time. The figures in brackets are only a rough approximation to the thickness in feet, and are given provisionally, merely to convey an idea of the proportionate volume of each division.

Lower Group.

Lower group.

1. Conglomerates composed of pebbles of quartz, jasper and greenish slate, in a greenish arenaceous matrix. Seen on the north shore of Thunder Bay. (70)

2. Chert layers, mostly thin and having a ribbon-like appearance in cross section. The mass is generally dark, but some light-colored layers occur. Thin beds of dolomite sometimes separate the chert layers from one another, and argillaceous layers are also occasionally interstratified; while bands of dolomite, which are themselves sometimes separated by argillaceous beds, are interstratified with the foregoing. The chert bands contain iron pyrites in specks, nodules and thin interrupted layers. A mineral resembling anthracite also occurs in the rocks of this and the following division. Seen at the eastern extremity of Thunder Bay, and near the five-mile post on the Red River road. (300).

3. Darkly colored massive argillites and flaggy black shales, the mass being characterized by numerous vertical joints, running in two directions, and dividing it into blocks of a very symmetrical character. The shaly portions hold regularly formed spheroidal concretions of various sizes. Trap beds are associated with these rocks along the north shore of Thunder Bay, at the Thunder Bay Mine and in the township of McIntyre. The shales are seen on the lower part of the Kaminitiquia River, especially at the Grand Falls, and along the coast of Lake Superior, between Fort William and Pigeon River, while an example of the massive variety may be seen in the workings at the Thunder Bay Mine. (450)

4. Gray argillaceous sandstones and shales, mostly thinly and evenly bedded, fine grained and slightly calcareous. Examples of both of these rocks may be observed on each side of Thunder Cape, and in the township of McIntyre. In the southern part of this township, and at the north-western corner of Neebing, bands of sandstone, supposed to belong to this division, occur, containing a large percentage of magnetic iron ore. (400).

Upper Group.

5. Alternating red and white dolomitic sandstone, with a red conglomerate layer at the bottom, occurring on Wood's Location, Thunder Cape. Mr. Macfarlane finds the red sandstone to contain $12\frac{1}{2}$ per cent. of carbonate of lime, and 11 per cent. of carbonate of magnesia. (40). Upper group.

6. Light gray dolomitic sandstone, with occasional red layers, and spots and patches of the same color. These sandstones occur along the south-west side of Thunder Bay, and on Wood's Location, where Mr. Macfarlane found them to contain 18 per cent. of carbonate of lime and 12 per cent. of carbonate of magnesia. (200).

7. Red sandstones and shales, interstratified with white or light gray sandstone beds, frequently exhibiting ripple-marked surfaces, and also with conglomerate layers, composed of pebbles and boulders of coarse red jasper in a matrix of white, red or greenish sand. (500).

8. Compact light reddish limestones (some of them fit for burning into quick-lime,) interstratified with shales and sandstones of the same color. (80).

9. Indurated red and yellowish-gray marl, usually containing a large proportion of the carbonates of lime and magnesia, the amount varying in specimens analysed by Mr. Macfarlane, from 21 to $34\frac{1}{2}$ per cent. of the former and from $7\frac{1}{2}$ to $13\frac{1}{2}$ of the latter. This division runs through the centre of the peninsula between Thunder Bay and Black Bay, and may, in this region, have a thickness of 850 feet or more. (850).

Upper Copper-bearing series.

10. Red and white sandstones with conglomerate layers, the red sandstones being often very argillaceous, and variegated with green spots and streaks, and having many of their surfaces ripple-marked. These rocks are found all along the north-west side of Black Bay as far up as the township of McTavish. (200).

11. On the opposite side of Black Bay, conglomerates and sandstones, mostly of light color, are interstratified with layers of trap, often amygdaloidal, and succeeded by beds of trap, largely developed in the peninsula between Black Bay and Lake Superior, and perhaps belonging in part to the next division. (6,000 to 10,000).

12. The great crowning overflow of columnar trap, which caps the hills from the Pigeon River to the Kaminitiquia, and forms the summit of Thunder Cape. It is characterized by numerous joints, dividing it into large columns at right angles to the plane of the mass. The rock is hard, more or less coarsely crystalline, and composed principally of varieties of augite and feldspar, with magnetic iron.

Unconformable trap.

While different portions of this series were found overlying unconformably, in some places the Laurentian, and in others the Huronian series, the additional facts, which have been observed during the past summer, leave little doubt that the great trap overflow, part of which has been mentioned as crowning Thunder Cape, rests in different places, sometimes unconformably, upon different members of both the upper and lower groups of the Upper Copper-bearing series. Sir W. E. Logan has already pointed out a want of conformity between it and the limestones and sandstones (9 and 10), and noticed the more horizontal attitude of the overlying trap. (*Geology of Canada*, pages 70 and 79.) On the south side of the lower reach of the Kaminitiquia, and in the country south-eastward from that river, to the shore of Lake Superior, the trap is found resting upon the almost horizontal shaly, cherty and jaspery beds, belonging to the lower part of the series. In 1868, Mr. McKellar observed the gray argillaceous sandstones (4) running under the trap on the north side of Thunder Cape; and last season, Mr. Macfarlane detected the higher conformable dolomitic sandstones and conglomerate layer (5) also underlying the trap, and in unconformable contact with it, on Wood's Location on the south side of the cape. On the west side of Nipigon Harbor, the same columnar trap is seen resting upon indurated red marl, believed to belong to the ninth division of the foregoing list. In the valley of the Black Sturgeon River, the same trap appears to overlies conformably the almost horizontal sandstones, red shales and marls; while in the neighborhood of the portage from Black Sturgeon Lake to Lake Nipigon, a similar rock is associated with beds of light gray sandstone and dark compact argillite in a vertical attitude; a great mass of trap of the same character, occurring on a

higher level, appears as if it might overlie the whole unconformably. Additional details in regard to these rocks, as they occur on Lake Superior and around Lake Nipigon, will be given further on, but much remains to be done before their sequence is properly worked out.

The age of the Upper Copper-bearing rocks has always been considered as doubtful, and although provisionally classified with the Lower Silurian, the name which they received was intended merely to distinguish them from the Huronian, or Lower Copper-bearing series. It has been mentioned by Sir W. E. Logan in the *Geology of Canada*, page 85, that the difficulty in determining their age arises from the absence of fossils of any kind. As, however, new facts accumulate in regard to them, it becomes probable that they may now be considered as of Permian and Triassic age. Being of a different general lithological character, as shewn in the foregoing list, and much greater thickness than the Lower Silurian rocks of any contiguous part of the continent, and being without fossils, which are generally so abundant in these rocks, are all facts unfavorable to the supposition of their being of Silurian age; while the prevalence of such great volumes of marls and sandstones charged with the red oxide of iron, and of great overflows of basalts, amygdaloidal and other trap rocks, the peculiar composition of the dolomitic sandstones, together with the presence of various zeolites and native copper, and the existence of brine springs, cause them to bear a strong resemblance to the rocks of Permian or Triassic age in Nova Scotia.

Age of Upper
rocks.

THE THUNDER BAY REGION FROM PIGEON RIVER TO BLACK BAY.

The shore of Lake Superior, from the boundary line at Pigeon River to the mouth of the Kaminitiquia, is overlooked by bold cliffs, coming close to the lake, and rising to a height of from 500 to 1000 feet above its level. This part of the coast, as pointed out in the *Geology of Canada*, p. 77, is occupied by the shales of the lower group, while the higher hills are all capped by the great basaltic trap overflow, which, as already mentioned, appears to constitute the newest member of the whole series. The same rocks seem to occupy the entire area northward to the Whitefish Lake and River, where they terminate in bluffs facing the north-west, similar to those which face to the south-east on the shore of Lake Superior. A corresponding arrangement marks the northern boundary of this area, where, to the south of the Kaminitiquia, below the mouth of the Whitefish River, and nearly corresponding with the southern boundary of the townships of Neebing and Paipoonge, high north-facing bluffs of trap, resting upon the lower members of the series, overlook the valley of the river. The shales and associated rocks, which crop out at a low angle from beneath the trap, continue, however to the north side of the lower stretch of the river.

Rocks of the
shore.

Their northern boundary would be roughly indicated by a line drawn from the Grand Falls, to a point on the shore of Thunder Bay, about six miles east of the mouth of the Current River.

Jasper rocks.

As pointed out in the *Geology of Canada*, p. 67, the lower members of the formation, which underlie the trap in this region, consist, in ascending order, principally of conglomerates, chert beds, hard shales of a bluish-black color, with some dolomite layers, and sandstones. Interstratified beds of more or less crystalline dark colored trap also occur in several parts, particularly towards the bottom of the series, and dykes of the same rock are common. The whole formation has a general dip, at a very low angle, to the south-eastward, or towards the lake. The darkly colored cherty and jaspery beds are often finely mottled with darker and lighter shades of green and spots of black and red. Sir W. E. Logan has referred to the occurrence of pebbles of this character on the shores of Thunder Bay. The rock was found in place on the flanks of Rabbit Mountain in the township of Paipoonge, three miles south of the Kaminitiquia River. Bands of reddish jasper were found in the slates on the opposite side of the river, at about the same distance from it. The occurrence of upwards of one hundred feet of the dark hard argillaceous shales, lying nearly horizontally at the Grand Falls of the Kaminitiquia River, is noticed in the *Geology of Canada*, page 68. Similar rock was found *in situ*, in several places on the river below the falls, the lowest being on lot 13, range A., about six miles from its mouth. It was also traced for two or three miles up the bed of the Slate River, which enters the Kaminitiquia, on the south side, near the east town-line of Paipoonge.

A trap dyke, curiously weathered, and standing up conspicuously out of the shale, crosses the stream about half a mile above its mouth. The bed of the Whitefish River is much encumbered with boulders, but the shales are seen here and there in the lower part of its course. At about twelve miles south-west of Fort William, and two or three miles north-west of the shore of Lake Superior, opposite Pie Island, a lake occurs, called Ka-zee-zee-kitchi-wa-ga-mog, which was surveyed by Mr. W. W. Russell, of our party. It was found to be seven and a-half miles long, in a north-east and south-west course, and one mile wide in the middle, and surrounded with high bluffs of trap, like that crowning McKay's Mountain. Its surface has an elevation of several hundred feet above Lake Superior, and Sucker Brook, which discharges its waters into the lake, rushes down over the underlying almost horizontal shales. These contain numbers of singular spheroidal concretions, similar to those observed by Sir W. E. Logan in the shales of the same formation, in the bed of the Kaminitiquia.

A river entering Lake Superior, between Pine River and Sucker

Brook, called by Mr. McKellar Cloud River, was followed by him to Cloud Lake, a distance of about six miles from its mouth. He found the shales and associated rocks of the lower group all along the bed of the stream, while the tops of the hills were composed of the trap of the crowning overflow. The whole of the district between this part of the north-west shore of Lake Superior, and the Whitefish Lake and River, is described as very broken, with numerous lakes surrounded by bluffs of trap. Whitefish River, which was found to be unfit for canoeing, except for a mile or two from its mouth, does not flow from the lake of the same name. Its upward course is described as curving round to the northward at about twelve miles from its mouth. Whitefish Lake is about seven miles long from east to west, and about two miles wide. High trap bluffs are said to overlook it on the south side. Proceeding westward, shales, similar to those of the lower part of the Kaminitiquia, are reported as occurring between Arrow and Gun-flint Lakes, and a specimen of the dark variegated jasper of this series, picked up on the shore of the latter lake, where it was said to exist *in situ*, was given me by a gentleman who had just come through it in a canoe. The south shore of the lake is said to be steep, and it is probable that the great trap overflow extends thus far. The Upper Copper-bearing rocks would appear to terminate at the west end of Gun-flint Lake.

The stratified rocks, both of the mainland and the islands from Pigeon River to the Kaminitiquia, and from Thunder Bay for a considerable distance eastward, are cut by innumerable trap dykes of all sizes, running parallel to each other, in a northeasterly course. They, therefore, form a slight angle with the general direction of the shore, it having a more northerly trend.

The Hudson Bay Company's winter trail from Fort William to Basswood Lake, follows the Whitefish River, Lake, and Portage, in going from the Kaminitiquia to Arrow Lake, but this route is impracticable for canoes. Many years ago, Lord Selkirk had a waggon-road opened from the Paresseux Rapids on the Kaminitiquia, to Whitefish Lake, which was used as a summer route, in connection with the boundary-line chain of lakes. The valley of the Kaminitiquia, from the mouth of the river to the junction of the Whitefish, a distance of about twenty miles, is covered with yellowish sand and loam, underlaid, in the lower levels, by bluish-grey clay. The breadth of these alluvial deposits from north to south, on the dividing line between Neebing and Paipoonge, is about seven miles, and it is apparently greater here, than either above or below. The soil does not appear to be fertile, except close to the river, and towards the mountains on the south side, where hard maple occurs in groves, which are used by the Indians for sugar-making.

North of this alluvial tract, at the south-west corner of mining-lot 1,

Iron ore.

Herrick's survey, three-fourths of a mile north of the town-line of Neebing, nearly horizontal calcareous beds occur, containing small coral-like silicious concretions and vertical cylinders of chalcedony, transverse sections of which shew fine concentric rings resembling agate. Beds of dolomite are seen about the north end of lot 3, of the same survey. Sandstone, containing magnetic iron, is found on lots 1, 2 and 3, Herrick's survey. On the northern part of mining-lot 54, adjoining the last, black silicious shales occur, which, with the other strata in the neighborhood, have a slight dip to the eastward. An exposure of trap, supposed to be a dyke, appears in a swamp on mining-lot 55, between lot 3 and the north line of Neebing. At a place called the Algoma Mine, on the north-west corner lot (25 in the 5th range north) of Neebing, there is an outcrop of thinly-bedded, flaggy, hard, dark grey sandstone, largely composed of particles of magnetic iron, and weathering to a rusty color. A brook, with a perpendicular fall of fifteen feet, has here cut a channel through the rocks, and exposed about twenty feet of the beds, which lie almost horizontally, or dip very slightly to the north. A specimen, which appeared to represent the greater part of the mass, has been found by Mr. Broome, the chemical assistant to the Geological Survey, to contain 37.73 per cent. of metallic iron, so that the rock may be considered an iron ore. Three veins, one of them thirty-one feet in width, and holding galena, occur here. These, with the iron-sandstone, will be more fully described under the head of Economic Minerals. The same highly ferruginous sandstone, dipping very slightly east-north-east, is again exposed on the banks of a brook on mining-lot B, rather more than a mile north-east of the Algoma Mine.

Copper ore.

On mining-lot C, about two miles north-east of the Algoma Mine, a vein, which contains copper pyrites, and will be again referred to, cuts the same sandstone, which here has a horizontal attitude. At a mile from this locality, in a course bearing N. 35° E., and about the south end of mining-lot G, there is a north-east facing bluff, thirty feet high, composed of similar sandstone, having a slight dip to the south-westward. Following the same course, at half a mile from this locality, there occurs, on mining-lot H, an exposure, fifty feet wide of dark compact, fine-grained trap, running S. 75° W., (mag.), but whether belonging to a dyke or a bed could not be determined; and at about one mile, on mining-lot J, a south-facing cliff, of similar trap, about twenty feet high. Further on, another south-facing cliff of trap occurs, at three hundred and fifty yards from the last; and at half a mile, a high north-facing bluff of the same rock is met with on the north ends of lots J and K, running N. 75° E. (mag). About a mile to the east, on mining-lot L, this bluff sweeps around, and forms the termination of a ridge pointing to the east-north-east, which is seen conspicuously from Thunder Bay. The upper fifty feet or

more, at the termination of this ridge, consist of trap, but the black shales appear to run below it, in which case, it would belong to a bed interstratified with the sedimentary strata of the group under consideration.

On the east side of the Current River, three ridges, composed of similarly interstratified trap, each having a north-easterly course, are met with on the Thunder Bay Mining Company's location, and the lots adjoining it on the east, and a fourth runs in the same direction across the southern part of the Shuniah Mining Company's location. From Bare Point on the former location, a ridge of trap runs almost due west a considerable distance, and may also be an interstratified mass. The surface of the trap, on the south side of the point, dips south, at an angle of 20° to 25° , and the black shales are found on each side, close to it. The trap which is met with at the commencement of the Red River Road occurs in a similar manner. Along the north shore, from Bare Point, eastward to the head of Thunder Bay, a distance of twenty miles, nearly all the islands, including Kitchi-minis, or Big Island, and the extremities of almost all the points, are composed of trap, associated with the shales, and in most cases, resting upon the lower portion of the group. The Welcome Islands, opposite the mouth of the Kaminitiquia, and four miles from it, are composed of the grey argillaceous sandstones of the lower group, and trap, apparently belonging to dykes.

On the Kaminitiquia River, as indicated in the *Geology of Canada* page 68, the shales of this group come in contact with the older rocks, about one-third of a mile above the Grand Falls. In tracing eastward the line which marks the southern boundary of the Laurentian and Huronian rocks, it is found, after a few miles, to make a bay to the north, crossing the Red River Road, about ten miles from Thunder Bay, returning to it at four and a quarter, and recrossing again at three and a quarter miles. The interval is occupied by the thinly bedded black chert, hard dark shales, weathering black, and some arenaceous and conglomerate beds, which lie almost horizontally where they come up against the gneiss. On the bank of McIntyre's River, on mining-lot M, there is an exposure of arenaceous beds and dark slates, like those at the Grand Falls of the Kaminitiquia, all weathering to an iron-black. Some of the beds here are composed of small black hard rounded grains, in a white apparently silicious cement. The strata dip north 40° west (mag.) $< 15^{\circ}$, and have a thickness, in the exposed section, of one hundred feet or more. A brecciated vein, forty feet wide, which will be again mentioned, crosses the river on this lot. From the point where it intersects the road, at three and a quarter miles from Thunder Bay, the boundary of the gneiss runs north-eastward to the Current River, which it crosses on mining-lot S. At this place, the Laurentian rocks appear to be confined to a narrow breadth on

Trappean rocks.

Boundary of
Laurentian and
Huronian.

the river, and to be flanked by the black shales on the south, and by the dioritic slates of the Huronian formation on the north.

Limit of Copper-bearing rocks.

From the intersection of Current River, the southern boundary of the older formations runs about due east, coming to the shore of Thunder Bay near Goose Point, seven miles from the mouth of the river. Continuing eastward, it cuts off all the points, (the metamorphic rocks being seen at the bottoms of the coves), along the north coast of Thunder Bay, to within four miles of its head, where it strikes inland, with a north-easterly bearing. Between the Current River and the head of the bay, the Upper Copper-bearing rocks repose, in some places, upon the Laurentian, and in others upon the Huronian series. At the Thunder Bay Mine, one of the thick beds of trap, already referred to, is underlaid by about fifteen or twenty feet of alternating beds of dark shale, impure dolomite, argillite, and what appear to be diorite layers. These are followed, in descending order, by massive dark olive and drab-grey argillaceous slate, about fifty-five feet of which have been cut in the shafts, the whole lying almost horizontally. An exposure of dolomite occurs about a quarter of a mile north-east of the mine, which is two and a half miles north-east of the mouth of Current River, and one mile north-west of the shore of Thunder Bay.

LAURENTIAN AND HURONIAN SYSTEMS.

Laurentian.

Northward from the limit of the Upper Copper-bearing rocks, which has just been defined, between the Grand Falls of the Kaminitiquia and the head of Thunder Bay, the country is occupied partly by Laurentian and partly by Huronian rocks, to a distance of about eight miles from the former, and about sixteen from the latter. The distribution of the two formations is represented, as accurately as possible from present data, upon the accompanying plan. North of this area is the country around Dog Lake, which is all Laurentian, so far as known. The gneiss of the Dog Lake region is remarkable for being distinctly stratified, and containing much mica, while that of the outliers to the south is very massive, and generally rather of the character of syenite and granite. The Huronian rocks of this region consist of slates, some of them dark green and composed of hornblende, some greyish-green and dioritic; others are light-colored, fine-grained, quartzose, somewhat nacreous micaceous schists; while dioritic slate-conglomerates, quartzites, fine-grained felsites, massive diorites, ribboned jasper and iron ore, also occur.

Dog Lake.

Dog Lake is of an irregular V-shape, the apex, at which the outlet occurs, being pointed to the south-west. From the outlet, one arm stretches north-eastward fifteen miles, while the other extends east eighteen miles. The breadth of the body of the lake, between the junction of the two arms

and the outlet, is from two to four miles. From the eastern extremity of the lake, the general strike of the gneiss is westward, with the course of the longer arm, gradually curving round, till at the outlet it becomes south-west. Following down the Kaminitiquia River, from the outlet of Dog Lake to near the junction of the Mattawa River, where the gneiss terminates, the strike continues to curve a round from south-west to south, and finally to south-south-east. On the south shore of Dog Lake, about one mile east of the Little Dog Portage, the gneiss, which is coarse-grained, and reddish, is full of irregular branching veins, (some of them a foot thick) of flesh-colored feldspar in large crystals. They run mostly with the stratification, which is here on edge, and striking S. 75° to 80° W. (mag.). In the neighborhood of the outlet, and along the Kaminitiquia River, to Little Dog Lake, the rock is principally mica schist. Laurentian gneiss.

Three miles below the head of Little Dog Lake, the gneiss dips N. W. at an angle of 70° . At the first portage, which is about three and a quarter miles below the same point, gneiss of a greyish and reddish color occurs, associated with mica-schist holding garnets. The strata, which are on edge, strike S., from 5° to 10° E., and are overlaid, unconformably, by a mass of rather fine-grained, dark reddish-grey syenitic granite, containing greenish and yellowish crystals of triclinic feldspar. At from three and a half to four miles below the first portage, reddish gneiss occurs, dipping eastward at an angle of 65° to 75° . The junction of the Laurentian rocks and the greenish Huronian slates, occurs on the Kaminitiquia River, about a quarter of a mile above the mouth of the Mattawa. Eight miles east of the Kaminitiquia, the line between the two formations crosses the Old Dog Lake Trail, at fifteen miles from Thunder Bay. Northward from this point, the trail, for two and one half miles, passes over massive red syenite, studded with large crystals of flesh-colored orthoclase feldspar, which give it the appearance of a very coarse porphyry. It shews no trace of stratification or lamination of any kind, and the feldspar crystals, which measure from one to two inches on the side, have no regularity of arrangement. At about eighteen miles from Thunder Bay, the trail crosses a ridge of rather fine-grained reddish-gray granite, composed of about equal parts of quartz, feldspar and mica. Between the twenty-mile station and the southern bay of Dog Lake, which is about twenty-four miles from Thunder Bay, fine-grained micaceous gneiss and mica-schist, running south, 15° west, (mag.) with a vertical dip, are seen in places on the trail.

As already remarked, between the third and fifth miles the Red River Road passes over a spur of the Laurentian area, which lies between it and the Current River. Where it first makes its appearance on the road, at about three and a quarter miles from Thunder Bay,

Laurentian
rocks.

it consist of very light reddish-gray quartz rock, with a little feldspar, and small specks of black mica. About a mile further on, very dark green silicious slate and hornstone are met with, running N. 70° E. (mag.) and vertical. They are associated with a dark green coarse-grained massive rock, resembling diorite, and may belong to the Huronian series. About a quarter of a mile north of the five-mile post there is a prominent point of coarse-grained gray syenitic gneiss, containing large flesh colored crystals of feldspar. Thin bands of a black micaceous hornblende rock, and small compact reddish bands, run irregularly east and west in the mass. Dykes of black trap, which have a zig-zag appearance, owing to numerous small dislocations, cut it in a north and south course. One of these dykes was observed to enclose patches of the country rock.

The Dog Lake Trail leaves the Red River Road about the seventh mile, and soon comes upon the gneiss, which is exposed along it for a breadth of five miles, when the Huronian slates commence. It consists of reddish and grayish gneiss, alternating in thick and thin bands, and striking generally at right angles to the road, or about east-north-east and west-south-west; but at about a mile from its northern limit it appears to dip west at an angle of 60° .

At the ten-mile post, on the Red River Road, there is an outcrop of massive light reddish-gray syenite, containing more feldspar than quartz, and conspicuously marked with elongated crystals of black hornblende.

The band of gneiss, already mentioned as occurring on the Current River on mining-lot S, as well as another which crosses the same river about eight miles from its mouth, are believed to be spurs from this area.

Syenite.

Coarse grayish-red syenite occurs between two branches of the Current River, ten miles from its mouth, also on the shore of Thunder Bay, near Goose Point, and three miles north of it, and again near the shore, for three miles on each side of McKenzie's River. In each of these places it appears to form an outlier, surrounded by the Huronian slates. A similar rock was found by Mr. McKellar on the Current River, at nineteen miles, in a straight line, from its mouth, and the main body of the Laurentian gneiss is about one mile farther on. To the east of Current River, and at a distance of four or five miles north of Thunder Bay, there occurs a range of hills of gneiss and syenite, which continues eastward to Black Bay. A spur from this range comes out upon the west shore of Black Bay, at Granite Point, and a number of small outliers, surrounded by the red marls of the Upper Copper-bearing series, occur to the south of the range, in the township of McTavish. Granite Island, in Black Bay, is also Laurentian. The rock at all the last mentioned localities is pink, of a granitoid character, composed mainly of feldspar and quartz, not coarsely grained, and containing no mica and very little hornblende.

In ascending the Kaminitiquia, the Laurentian rocks are first seen at about one-third of a mile above the Grand Falls, where gray quartzose gneiss, containing some feldspar, is exposed at the second portage, and is overlaid by hornblendic, passing into dioritic schist, containing actinolite crystals and specks of iron pyrites, and dipping N. 5° W. (mag.) $<60^{\circ}$. A breadth of 150 paces of this rock is exposed at the head of the portage. At about four miles above the Falls, grey micaceous gneiss occurs at the next or third portage. It contains colorless quartz, with white and yellowish crystals of feldspar, and a little hornblende. The rock is of a massive character, and encloses short lenticular patches of mica-schist, running with the stratification, which dips N. 5° W. (mag.) $<75^{\circ}$.

Between the margin of the Upper Copper-bearing rocks, on the north shore of Thunder Bay and the Laurentian range, already described, all the country not occupied by the syenitic areas which have been mentioned, appears to be composed of rocks of the Huronian series. These consist of diorites, dioritic conglomerates, hornblendic and fine-grained micaceous slates, with some quartzites. In ascending the Current River, the first four miles are upon the Upper Copper-bearing rocks, but beyond this, to a distance of about twenty miles in a straight line from its mouth, Mr. McKellar found nothing but Huronian slates of different kinds, with the exception of the gneiss band, at about eight miles, which has been already referred to. At the end of this distance he came upon the south-east border of the Laurentian area surrounding Dog Lake.

Huronian
rocks.

On the old trail from Thunder Bay to Dog Lake, the space between the twelfth and fifteenth mile-posts is occupied by Huronian slates. Those on the south side of the interval have a green chloritic appearance, hold grains and cubes of iron pyrites throughout, and irregular patches of red and reddish-gray feldspar in the planes of bedding or cleavage, which is almost vertical, and runs N. 80° W. From thirteen and one-half to fourteen miles, the rock is a very dark hard greenish clay-slate, apparently on edge, and running generally N. 60° E. At fourteen miles, a band of a somewhat arenaceous character occurs, striking N. 65° E. It has been already mentioned, that in descending the Kaminitiquia River, the gneiss ends, and the Huronian slates begin, at about one-fourth of a mile above the junction of the Mattawa. Opposite the mouth of this river, the rock forming the bank of the Kaminitiquia is a fine-grained rather soft dioritic slate of greenish and bluish-gray colours. The general strike of the cleavage or bedding is east and west, varying ten degrees each way, and its dip southward, at an angle of about seventy degrees. It is cut by numerous short irregular veins or patches and strings of white quartz, holding a little lilac-coloured petalite. The course of these is about N. 25° E. (mag.) On the tops of the hills, near the south side of

Huronian
rocks.

Jasper and iron
ore.

the Mattawa, and about one mile from its mouth, dark green silicious clay-slate occurs on edge, and runs N. 85° W. Massive and laminated bands, and bands of different shades of colour alternate. It contains numerous quartzose strings, weathering yellow, also reticulating strings and irregular parallel veins and strings of pure quartz. Spots or kernels of a lighter colour and more granular character than the rest of the rock run in irregular groups through it. The Huronian slates are said to continue westward, the whole length of the Mattawa River, and along the shores of Shebandowan Lake, from which it flows Mr. G. F. Austin, P.L.S., informed me that after going a few miles up the river he found the slates to assume a softer and more talcoid character than they possess at its mouth. A specimen of light-coloured, very fine-grained quartzose, somewhat nacreous, micaceous schist was brought by Mr. Andrew Bell, P.L.S., and one of dark greenish-grey clay-slate, by Mr. Thomas Monro, C.E., of the Public Works Department, from Shebandowan Lake; and the Indians have brought to me specimens of greenish hornblendic and dioritic slates from the same lake. In the hills on the left side of the Kaminitiquia River, a finely banded rock, made up of jasper and magnetic iron, occurs at the distance of one mile south-east of the junction of the Mattawa. The alternating beds are usually not more than from one-half inch to two inches thick, and present a very striking contrast; the jasper being brown or bright red, while the magnetic iron is black, finely granular and glistening. The beds are somewhat contorted, but their general strike appears to be about east and west. On the west side of the Kaminitiquia River, at about a mile and a-half below the Mattawa, the same ribboned jasper and iron-ore rock occurs, associated with black arenaceous layers, semi-translucent banded chert, approaching chalcedony, and dark fine-grained hard ribboned argillite or felsite, having a conchoidal fracture. These strata are considerably contorted, and dip at high angles, but their general course appears to be north-westward. On higher ground, overlooking the river at this locality, and possibly unconformable to the strata just described, are thick beds of fine-grained greenish-gray diorite, mottled with small light red patches, with others of a greenish-grey diorite, coarsely porphyritic from the presence of numerous crystals of greenish feldspar. The beds vary from one foot in thickness, up to fifteen or twenty feet, and strike N. 65° W. (mag.), with an inclination to the north-eastward of about 75°. Following the river downward, the dark green hornblendic, and lighter fine-grained mica-slates are observable wherever the rock is exposed, as far as the band of gneiss, which has been already mentioned as occurring at about four miles above the Grand Falls. The dip is northward, at angles varying from 50° to 70°. At a short portage, about a mile above the place where the gneiss occurs, there is a

band of slate of a rather lighter colour than usual, and weathering yellow, from the presence of numerous grains of iron pyrites. It also holds grains of clear quartz, about half the size of peas, and in the cleavage planes, scales of silvery mica. In the *Geology of Canada*, (page 65) it is mentioned that in this part of the river some very large boulders with a brownish or blackish matrix, having much of the trappean aspect belonging to some of the varieties of the slate-conglomerate, and holding blood-red jasper pebbles and balls of iron pyrites, have been observed, resting upon the green slates, and apparently not very far removed from the parent rock. Huronian
rocks.

Strawberry Brook joins the Kaminitiquia on the east side, about half-a-mile below the Mattawa. The lower reaches of these two streams, entering from opposite sides, lie almost in the same line, and appear to run on the same belt of rock. Following the Red River Road from the Kaminitiquia towards Thunder Bay, the green Huronian slates are the only rocks seen to within ten and one-half miles of the latter, where the red syenite, already mentioned, is met with. At thirteen and one-half miles, the green slate holds numerous specks of iron pyrites, and is cut by a north and south trap dyke, about five feet wide. In the neighbourhood of the eleven-mile post, similar slates, holding strings of quartz, are thickly spotted with white grains. The strike is here about north and south, apparently conforming with the western side of the gneiss area already referred to, between this road and Current River.

THE PENINSULA BETWEEN THUNDER BAY AND BLACK BAY

is occupied entirely by the rocks of the Upper Copper-bearing series. The northern limit of the formation would be approximately marked by drawing a line from a point six miles north of the extremity of Thunder Bay, eastward to Granite Point on Black Bay. The lower group, comprising the chert bands, shales and argillaceous sandstones, is found near the water's edge, all along the south-east shore of Thunder Bay, from its head to Thunder Cape. From the head of the bay, these rocks extend inland to Silver Lake, a small sheet of water at a distance of four miles, in a northerly course, from the shore. In approaching the Cape, and when within about six miles of its extremity, the line marking the summit of the lower group sweeps round and comes to its south side, near Ryanton, which is situated about the middle of Wood's Location. On Thunder Cape, a cliff, three miles long, rises to a height of 1,850 feet above the water, and forms the most conspicuous headland on Lake Superior. The upper part of the cliff is composed of the columnar trap of the crowning overflow (12.) It is of a dark color and crystalline. Mr. Macfarlane has observed that the

coarsely grained varieties prevail towards the summit, and those of a finer texture near the contact with the underlying strata; and a similar fact was noticed by myself in the Nipigon country. This trap is composed of grayish and greenish feldspar and hypersthene, with a little hornblende and magnetic iron. According to Mr. Macfarlane, the rock would be called hyperite. (*Canadian Naturalist*, new series, vol. iv, page 460.) The argillaceous sandstone beds, which underlie the greater part of the trap in the cliff, are almost horizontal, but still their surface appears to have been denuded or disturbed before the trap was laid upon it; and on the western part of Wood's location, where the eastern termination of the cliff occurs, Mr. Macfarlane found a distinct want of conformity between the great trap overflow and the underlying conglomerates and dolomitic sandstones (5), which rest conformably upon the argillaceous sandstones. The light gray dolomitic sandstones (6) sweep round from the shore of Lake Superior, on the eastern part of Wood's Location, to a point on the south-west side of Thunder Bay, about six miles from Thunder Cape, from which they continue north-eastward, forming a conspicuous cliff close to the shore of the bay, all the way to its extremity, and beyond it to Silver Lake. North of this lake, they are again found on the south side of the Laurentian range. The red sandstones and shales, interstratified with whitish sandstones and conglomerate layers (7), and the indurated red and yellowish-gray calcareous marls (9) run longitudinally, with a breadth of from two to four miles, through the whole length of the peninsula; and in the township of McTavish, they appear to spread out all along the south flank of the Laurentian range from Silver Lake to Granite Point, a distance of about eleven miles. In this interval, numerous spurs and outliers of the syenite protrude through the red marls. The compact light reddish limestones (8), which come between the two last mentioned sets of rocks, and which may prove valuable for burning into quick-lime, occur on the shore of Lake Superior in the vicinity of the eastern side of Wood's Location. The white and the red argillaceous sandstones with conglomerate layers (10) occupy the western side of Black Bay, from its entrance to McEachran's Point in the township of McTavish, and may extend inland, in some places, to a distance of two miles. Several lakes occurring on this peninsula, which have not hitherto been represented on the maps, are shown on the accompanying plan. We are indebted principally to Mr. P. McKellar for these new geographical features. The lake entering Wood's Location, but lying principally to the north of it, is estimated by Mr. Hugh Wilson, P.L.S., to be six miles long and three miles wide. The small lake on Thunder Cape has an elevation of several hundred feet above Lake Superior.

BLACK STURGEON RIVER.

The country around the head of Black Bay, and across to Nipigon Bay, is low and level. The general upward course of the Black Sturgeon River, which enters the northern extremity of the former bay, sweeps round in a regular curve from north to north-west, and at the end of forty-four miles reaches Black Sturgeon Lake. This lake may be described as lying to one side of the general course of the river, the upper section entering the southern extremity of the lake only one mile and three-quarters west of the point where the lower section discharges from it. The upper section of the river, in ascending from the lake, is found to have, at first, a very tortuous course, with low land on each side. At three or four miles south-west of the point at which it enters Black Sturgeon Lake, it divides into two branches, in following either of which, we pass through a lake; Pike Lake on the more southerly branch being about two miles across, and Cyclas Lake on the other, about one mile. At about fifteen miles from Black Sturgeon Lake, the southern branch enters a hilly country, and the northern branch at about thirteen miles; but east of this range, the whole tract through which the two branches pass is comparatively level, and the country continues so to Black Sturgeon Lake and the lower section of the river. The upward course of the south fork of the river just mentioned, extends south-westward in two principal branches (each proceeding from lakes) to a distance of about thirty miles beyond the point at which it enters the hilly country; so that the whole length of the general course of the river would be about ninety miles, but following its windings, about double that distance. Black Sturgeon Lake stretches in a north-westerly direction. It measures two miles in width by thirteen in length, and comes within about one mile of the southern arm of Black Sturgeon Bay on Lake Nipigon. A valley, paved with rounded boulders, extends from one to the other. The two lakes appear to have nearly the same level. I was informed by an old Indian that, in former times, whenever the water happened to be high, a small quantity flowed from Lake Nipigon into Black Sturgeon Lake, but that it had altogether ceased to do so for the last thirty-five years. The water of Black Sturgeon Lake and River is very dark, while that of Lake Nipigon is remarkably clear. A small brook enters the south arm of Black Sturgeon Bay, and its dark-colored water fills the arm northward to the open bay, where it mingles with the clear waters of Lake Nipigon, which could not happen if the water flowed from this arm into Black Sturgeon Lake. A pond, one quarter of a mile long, occurs on the portage, and it is just possible that a little water may find its way, under the boulders, from Lake Nipigon to Black Sturgeon Lake; but, if so, the quantity must be very small, as the Black Sturgeon River appears to be as large where it enters as where it leaves the lake, although several large brooks fall into the latter on either

Geographical
details.

Black Sturgeon
River.

side, and appear to be quite sufficient to compensate for the evaporation. A well marked water-line, three feet over the summer level of 1869, was observed on the rocks in many places around the shores of Lake Nipigon. The Indians say that previous to thirty-five years ago, the water had stood for a long time at this height, and that it then gradually fell for several years, until it reached its present level. Leaving Black Sturgeon Lake, the river of the same name runs nearly straight, in a south-easterly course, and is very rapid for six miles and a-half, when it enters Nonwatan Lake. This picturesque sheet of water is three and a-half miles long, from north to south, and one mile and a-half wide in the middle. It receives a considerable stream called Nonwatan River, from the westward, the upward course of which lies south-westward for a considerable distance, through a level country. Leaving this lake, the Black Sturgeon River flows sluggishly between marshy borders for the distance of a mile, to Lake Nonwatanose (or Little Nonwatan), one mile in diameter and nearly round. At two miles and three-quarters below this lake, we come to Esh-quanonwatan Lake, two miles in length, and the last one on the river.

It has been mentioned that a level tract of land occurs on the west side of Black Sturgeon Lake, and along the upper section of the Black Sturgeon River. This continues down the western side of the lower section to a distance of about three miles below the last lake, from which point the river, for a distance of fifteen miles, is approached, at intervals, on either side by high hills, leaving a valley of perhaps three or four miles in width between them. Below this, the country again becomes level to Black Bay on Lake Superior.

From the last lake, the river is extremely crooked all the way to its mouth. It is interrupted by numerous short rapids, mostly over boulders, between which the current is slack, with deep water and a muddy bottom. The banks are composed of fine sandy clay, and vary from four to forty feet in height. Descending from Black Sturgeon Lake, our larger canoes, manned by white men, ran all the rapids in the river, excepting one, in which there is a slight perpendicular pitch. The river is observed to increase rapidly in volume all the way from Black Sturgeon Lake to its mouth, where it has become one of the largest rivers entering Lake Superior. The principal tributaries join it from the west side, the country between this river and the Nipigon not being of sufficient breadth to afford large streams, and such as do exist between the two rivers fall mostly into the latter. The largest of these western branches falls into the Black Sturgeon River about fifteen miles from its mouth.

Geological description.

Lower Section. High hills approach the Black Sturgeon River upon the west side, beginning to the southward at a point about eight miles from

the mouth, and continuing at distances varying from less than one mile to more than three miles from its banks, to within two or three miles of the lowest lake. Those nearest to Black Bay have an elevation of about a thousand feet, but the height diminishes very much in receding from Lake Superior. These hills appear to be composed principally of the reddish sandstones, shales, and indurated marls of the Upper Copper-bearing series, lying almost horizontally, and capped by an overflow of columnar trap of varying thickness. The rocks exposed all along the bed of the lower section of the river, from Black Sturgeon Lake to the mouth, belong, with a few exceptions, to the same series, being principally indurated marls and sandstones. Black trap occurs at the first rapid, one mile and a quarter below the lake, but from this point downward, indurated red marls, with light greenish layers, all lying nearly horizontally, are beautifully exposed along the banks of the river to Nonwatan Lake. At three miles below Esh-quanonwatan there is an exposure of dark brownish fine-grained compact felsite, ribboned with lines and patches of reddish and others of greenish color. It dips at a low angle, southward, and resembles some of the beds associated with the Upper Copper-bearing series in the Thunder Bay region, but may be Huronian. An exposure of trap is met with in the bank of the river, just above the main west branch, at about fifteen miles from the mouth, and another at about eight miles from the same point. No fixed rock was observed along the south-west side of Black Sturgeon Lake, except near its head, where black trap occurs on both sides, and continues down the north-eastern shore for seven or eight miles, when Laurentian gneiss is met with. From this point, a considerable area of gneiss stretches along the north-east side of the lake, towards the outlet. High hills of trap rise on the east side of Nonwatan Lake, and continue southward, with more or less regularity, for a distance of about sixteen miles, or to within twenty miles of Black Bay. At about sixteen miles from this bay, the hills on the east side are composed of greenish slates, supposed to be Huronian, striking about N. 70° E., and dipping at a high angle to the northward. From this locality, hills of reddish Laurentian gneiss run close to the river, in a continuous range, varying from five to seven or eight hundred feet in height, for a distance of about six miles towards its mouth. These hills form part of the western boundary of a Laurentian area, extending to the Nipigon, and which will be described in connection with that river.

Upper Section. No solid rock appears at the southern end of Black Sturgeon Lake, but pebbles of indurated red marl and impure limestone are abundant on the beach. The black trap occurs at the first rapid on the north branch of the upper section of the river, about six miles south-west of the lake. At the head of this little rapid, a brine spring is found on the north bank of the river. It rises among loose masses of the trap, in the imme-

diate vicinity of the same rock *in situ*. Angular fragments of indurated red arenaceous marl, some of them having light spots, were also common in the neighborhood, and it is probable that the brine proceeds from strata of this nature underlying the trap. Small ridges of the latter rock were crossed, here and there, in making two traverses between the north and south branches. It has been mentioned that a range of hills crosses the northern branch at about thirteen, and the southern at about fifteen miles from Black Sturgeon Lake. This range appears to run south-eastward for a considerable distance towards Black Bay. Its eastern flank is composed of dark coarsely crystalline trap. Just behind the east slope of the range, and between the two branches of the river, a small lake is met with, at which, I was informed by the Indians, pipestone, like that of Red Rock, (a light-red argillaceous limestone) occurs *in situ*. The shingle in the bed of the south branch, for several miles east of the trap range, consist principally of fragments of indurated calcareous marls and shales of various colors.

NIPIGON RIVER.

The Nipigon River empties into the head of Nipigon Bay, which is the most northern point of Lake Superior. It is the largest river flowing into the lake, and differs from all the others in having clear water. The following appears to be about the order, in size, of the twelve largest rivers entering Lake Superior, judging principally by the area which each appears to drain: Nipigon, Kaminitiquia, Black Sturgeon, St. Louis (in U. S.) Pic, Michipicoten, Goulais, Batchawana, Black, Ontonagon (in U. S.), Montreal, and Current. The character of the Nipigon River and its size, together with the fact of its draining the largest area tributary to Lake Superior, and connecting this with a lake of such an extent as Nipigon, entitle it to be considered as the continuation of the St. Lawrence beyond Lake Superior. The general upward course of the Nipigon is due north, (astronomically) its mouth and the exit from Lake Nipigon being in about the same longitude. Between these points, however, which are thirty-one miles apart, the river makes a slight curve to the westward. Four lakes occur in its course, to which, in the absence of any other names, we gave those which are shewn on the accompanying map. The lowest of them, Lake Helen, is only one mile from Red Rock, a Hudson Bay Company's post at the head of Nipigon Harbor. At the outlet of this lake the river is very narrow, apparently only about 100 yards wide, and sweeps around with a strong current (estimated by Admiral Bayfield at four and one-half knots an hour) for a distance of about half-a-mile, between banks of boulder-drift, from thirty to forty feet high. Lake Helen, which runs due north

Geographical details.

Four lakes.

is about eight miles long and one mile wide. The upward course of the river leaves the west side of this lake nearly at right angles to the shore. For six miles from this point, in a north-westerly direction, it has a width of about five chains, with deep water, and a moderately strong current, flowing in a bed of alluvial sandy clay, with Laurentian gneiss close to the east side, sometimes approaching quite to the brink of the river; while on the west side, the same rock comes to the water towards the end of this stretch. Here the river makes a sharp bend to the right, and is broken by a slight chute at Camp Alexander. At one-quarter of a mile above this point the Long Rapids begin, and continue for two miles; but in ascending the river they are avoided by turning into a brook on the west side, and following it for about three quarters of a mile, and from it a portage of one mile and a-half brings us to the foot of Lake Jessie. This lake, which is three miles long, and studded with islands, is separated from Lake Maria, immediately above it, and two and one-half miles in length, by The Narrows, six or eight chains wide, in which there is a strong current, with a fall of six inches or more.

Lakes and
portages.

A very high west-facing cliff of columnar trap approaches the river from the south-westward, at the head of Lake Maria, and runs from this point, in a tolerably straight course, all along the east side of the river to Lake Nipigon. Trap cliffs also occur on the west side of the river from Lake Maria to Cedar Portage, the distance being two miles. This portage is 250 yards long. A mile and a-quarter above it there is another portage, of fifty yards, over an island in the middle of the river. Three quarters of a mile above Island Portage, the One-Mile Portage, (2600 paces) begins. At rather more than one mile from the head of this portage the river breaks in a white foaming chute, across a narrow ridge of trap, which separates Lake Emma from the lower level. A narrow arm, in continuation of the course of the river, just below White Chute, and parallel with the east shore of Lake Emma, but on a lower level, extends beyond the chute to a distance of about a mile, where a portage of 230 yards is made across the low trap ridge to the lake which has just been mentioned. This lake is nearly four miles long. Between it and the point at which the river leaves Lake Nipigon, a distance of some six miles, four principal rapids occur, the lowest of which is seen where the river enters the northern extremity of Lake Emma. The canoe route turns aside from the waters of the Nipigon at the north-west angle of this lake, and for one-quarter of a mile follows a brook flowing from Lake Hannah, which has a slightly higher level than the last lake. Four miles more, in a north-westerly course, brings us to the head of Lake Hannah, from which Flat Rock Portage, about one mile in length, carries us to the shore of Lake Nipigon.

The following list shews approximately the levels in ascending the river, and the height of Lake Nipigon above Lake Superior. The three princi-

Levels.

pal ascents, namely, at the Long, the One-Mile, and the Flat Rock Portage, were determined by observations with two aneroid barometers; the others were estimated as carefully as possible, on the ground.

	<i>Feet.</i>
Current between Red Rock and Lake Helen.....	2
Current in river from Lake Helen to Camp Alexander, six miles, at one foot per mile.....	6
Chute at Camp Alexander.....	4
From the last to foot of Long Portage, by way of Portage Brook.....	8
Rapids at Long Portage.....	137
Current in The Narrows, between Lakes Jessie and Maria.....	1
Current from last lake to Cedar Portage.....	1
Cedar Chute.....	10
Current from Cedar Chute to Island Chute.....	1
Island Chute.....	7
Current from the Island to the One-Mile Portage.....	2
Rapids at One-Mile Portage.....	45
Current from One-Mile Portage to White Chute.....	1
White Chute.....	6
Current in brook between Lakes Emma and Hannah.....	1
Rise from last lake to Lake Nipigon, (Flat Rock Portage).....	81½
Lake Nipigon above Lake Superior.....	313

Geological description.

Red marls and trap.

From a cove on the west side of Nipigon Bay, about four miles south of Red Rock, a belt of level sandy ground, which is swampy in some places, runs westward to the Black Sturgeon River. Hills of columnar trap, resting upon the indurated red marls and associated rocks, rise both to the north and south of this level tract, near Nipigon Bay, but they do not extend far westward. Near the Black Sturgeon River an isolated hill rises from the level ground. On the sides of this hill the red marls are frequently exposed, while the summit appears to be composed of trap. The hills of gneiss, which have been mentioned as running down the east side of the Black Sturgeon River, terminate at about ten miles from its mouth. From this point the southern limit of the Laurentian area runs northeastward to within about a mile of Red Rock, where the black trap is found resting upon horizontal beds of a gray shaly arenaceous rock. On the west side of the Nipigon the hills of gneiss approach the river between Lake Helen and Camp Alexander, and continue northward for some miles along the west side of Portage Brook, which joins the river on the lower side of the Long Portage. The whole country, from this section of the Nipigon River south-westward to the Black Sturgeon, as far as it is known, is composed of Laurentian gneiss, in a succession of high ridges, the depressions between them being generally occupied by long ponds or marshes.

On the east side of the river, in ascending from Lake Helen, the gneiss Gneiss. at first dips northward at an angle of about 70° , but soon changes to the opposite direction, the synclinal axis being about two miles from the lake. Beyond this the dip is uniformly northward, at high angles. The trap begins at Camp Alexander, and continues up the west side of the river, and of Lake Jessie, while gneiss, with a north-eastward dip, occupies the eastern side of the lake. At the head of the Long Rapids the trap, which is seen resting upon the gneiss, is close-grained and compact, while further away, on the east bank of the Portage Brook, it is of a coarser texture, and thickly spotted with crystals of whitish feldspar. The land is low on the western sides of Lakes Jessie and Maria, but somewhat hilly to the east of them. Gneiss occurs at the Narrows, between these two lakes; and on the east shore of Lake Maria, a short distance northward, there is a Mica schist. considerable display of mica-schist, dipping N. 10° E. $< 45^{\circ}$. Overlying this, at the north-east side of the lake, and just under the high trap bluff already referred to, there is a great thickness of quartzite, probably Huronian, dipping N. 20° E. (mag.) $<$ about 80° . Above this lake the river passes for two miles through a gorge in the trap. Mica-schist, holding an abundance of garnets, and running N. 50° E. (mag.), begins at Island Portage, one mile and a-quarter farther up, and continues to the One-Mile Portage, beyond which the black trap was the only rock seen *in situ* to the shore of Lake Nipigon, following the canoe route by the Flat Rock Portage. At the north-west end of Lake Hannah angular fragments of a hard coarse-grained gray sandstone are abundant, shewing that the parent rock is not far distant.

LAKE NIPIGON AND THE SURROUNDING COUNTRY.

Nipigon, the name by which the lake is commonly known, is a contraction of an Indian word signifying "Deep Clear-water Lake." Our plan of operations in making the survey has been already explained. The general outline of the lake we found to be elliptical, the longer diameter lying a little west of north, and measuring about seventy miles, while its breadth is about fifty miles. Lake Nipigon. The shore is, however, deeply indented by large bays, especially on the south side. Ombabika Bay, on the north-east side, is the largest in the northern part of the lake, being nearly twenty miles long, with an entrance only one mile wide. These indentations add greatly to the length of the coast-line, which measures 580 miles, without following the smaller bays and coves. This circumstance will, no doubt, be of much advantage in colonizing the land surrounding the lake, since it renders so much of it accessible from the water.

Lake Nipigon.

Nipigon differs from the other great lakes in being thickly studded with islands, adding much to the beauty of the landscape. It has been already mentioned that in the course of our survey we ascertained the size and position of about 460 of the islands, and located approximately about 100 more. These vary in size from eight miles, in their principal diameter, down to a few chains in length, but the numbers stated do not include any mere rocks, destitute of trees. Many islands, at a long distance from shore, could not even be located. Probably the whole number in the lake exceeds a thousand. Four of the largest islands range from five to eight miles in diameter, while others, measuring between two and three miles, are numerous.

The Nipigon River, which issues from the south-east side, is the only outlet of the lake. I have referred to the fact that, many years ago, according to the Indians, a small quantity of the water escaped into Black Sturgeon Lake. From our observations along this river, it would appear, as already stated, that the surface of the lake is about 313 feet over Lake Superior. The shores are generally bolder, and the water deeper on the southern and western sides than on the northern and eastern, where long sand-beaches and shallow bays are of frequent occurrence. Mr. William Armstrong, of Toronto, who visited Lake Nipigon in 1867, states that close to Echo Rock, a line 540 feet long was lowered without reaching the bottom. Although we did not actually ascertain the depth anywhere at a distance from land, it always appeared to be very considerable, and I have observed the Indians fishing in upwards of a hundred feet of water, within a stone's throw of the shore.

The following are the names, in order of apparent size, of the sixteen largest streams flowing into the lake, and their positions are shown on the accompanying map: Kay-oshk or Gull River, Na-me-wa-min-i-kan or Sturgeon River, sometimes also called the Poplar Lodge River, from the name of the Hudson Bay Company's post at its mouth, O-na-ma-ni-sagi or Red Paint River, Pick-i-ti-gouch-ing or Muddy River, Ka-bi-to-ti-qua or the river which runs parallel to the shore, Om-ba-bi-ka or Rising Rocks River, Wa-ba-nosh or Dawning Day River, Ka-ma-ka-te-wa-ga-mig or Black Water River, Posh-ko-ka-gan River, Ka-wa-ba-ton-gwa or White Sand River, Ka-ba-sash-kan-da-gi-sino River, Pa-jit-chig-a-mo or Look-out River, Sandy River, Katch-an-ga-ti-na-wi or High Hill River, Ka-nee-sha, and Ka-nee-sha-sing River.

The aspect of the country immediately around Lake Nipigon, and of the islands within it, is undulating and sometimes hilly, although level tracts of considerable extent occur in some places, and will be again referred to in describing the soil. The most prominent or noted elevations near the lake, are those of Three Mountain Point near Flat Rock

Portage, Grand Cape, the hills on the south-east end of Grand Island, Lake Nipigon. Tchiatang's Bluff on the east side of Black Sturgeon Bay, a low range terminating in Echo Rock near Nipigon House, Mount Royal on Jackfish Island (so called from its resemblance to Montreal Mountain), the Inner and the Outer Barn, Mount St. John, and the Sugar Loaf. The height of Echo Rock we found to be 241 feet above the lake, of the Inner Barn 622, and of the Outer Barn 574 feet above the same level.

In regard to geographical names, we endeavored to ascertain all those used by the Indians, both in reference to places on Lake Nipigon itself and in the surrounding country. These we always adopted in preference to any others. For the correct meaning and mode of spelling the Indian names, I am indebted principally to Mr. Henry De La Ronde, of Poplar Lodge. There are, however, many geographical features for which the Indians appear to have no distinctive names. When names of any other origin existed for these, we always adopted them. There still remained many localities for which we could hear of no designation whatever, and it then became necessary, for the convenience of description, to give names to them.

Geological description.

East Side.—The following geological description of the eastern side of Lake Nipigon from Flat Rock Portage, on the south side, to Meeting Point, at the northern extremity, is taken from Mr. McKellar's plans and notes.

Following the shore eastward from the portage, the only rock to be found, with the exception of an exposure of limestone, about to be noticed, is the black or dark gray columnar trap, supposed to belong to the crown-Trap rocks.ing overflow (12); until reaching a cove one mile north of Black Water River, where Huronian rocks begin. On Columbus Point and Prince Alfred's Island, which lies close to it, the trap is coarsely crystalline and contains much magnetic iron. It is cut by numerous ill-defined veins of bright red orthoclase feldspar, holding grains of semi-translucent quartz. In the vicinity of the outlet of the Nipigon River the shores are bold, rising from 50 to 200 feet above the lake, with but little soil. Both fine and coarse grained varieties of the trap occur here; the weathered surface of the latter often shewing large crystals of black pyroxene. East of the outlet a deep narrow bay, forming the south-eastern extremity of the lake, and called by the Indians Pi-jit-a-wa-bi-kong, runs southward parallel with the river. The ground is bold and rocky on each side of this bay, and rises to heights varying from 100 to 300 feet above the lake; while a prominent point on the east side, called Green Mountain, rises to a height of upwards of 400 feet.

Limestone.

The limestone which has just been referred to, is met with on the east side of Cook's Point, two miles west of the outlet, where it extends for a mile along the shore, and in some places rises from fifteen to twenty feet above the water. It is thinly bedded, and consists of alternating whitish and olive-green layers. The rock, which has a fine homogeneous texture and conchoidal fracture, is magnesian and argillaceous, and when burnt would probably form a good cement. Some indistinct forms, resembling fossils, occur in it, but nothing definitely organic was observed. The limestone band is generally horizontal, but in some places it is thrown into a series of small anticlinals, having their axes north and south. It is overlaid by the trap, which rises to a height of about 100 feet immediately above it. Near the contact of the two rocks the limestone is somewhat altered, being white and crumbling, as if calcined, while the trap holds reddish greenish and dark brown nodules and veins, together with small veins of white calc-spar and quartz. For a space of ten or twenty feet above the limestone, the trap is filled with red specks of oxide of iron, probably resulting from the pyrites which commonly prevails in the rock.

Huronian rocks.

From the bottom of the cove at which the Huronian rocks begin, a valley runs eastward from the lake, and is overlooked on the south side by a trap bluff, nearly 300 feet high. The rocks occupying the lower ground to the north, consist of dioritic slates, dipping generally N. 25° W. (mag.) < 83°. Some of the beds are made up of elongated masses, running with the stratification, and varying from a few inches up to one or two feet in their longer diameters. The inclosed masses are harder and more compact than the slaty matrix, but otherwise have much the same character and appearance. Quartz veins, running with the stratification, are very numerous. They are of a lenticular form, generally diminishing rapidly in thickness each way. Where one vein ends another usually begins at a few feet on either side of it. The largest are four or five feet thick in the middle. The quartz has a barren appearance, and nothing of a metallic nature was observed in any of the veins. Many of the slate beds on each side of them are chloritic, and have smooth shining surfaces. These Huronian rocks extend to the bight of the bay on the south side of Grant's Point, a distance of two miles and-half. Here the trap again makes its appearance, and occupies the shore to the south side of Sandy River, but it does not appear to extend far inland.

From this river the dioritic slates continue for five miles, terminating at a cove, three miles in a straight line, north of Poplar Lodge, which is at the mouth of the Na-me-wa-min-i-kan River. On the north side of Sandy River, they appear to dip southward at an angle of 45°, and at Poplar Lodge, N. 55° W. < 85°. In the vicinity of Poplar Lodge, besides the ordinary diorites and dioritic slates, there are chloritic slates and dioritic

slate-conglomerates. The enclosed masses in the last mentioned rock are both rounded and angular, and vary in size from small pebbles to boulders or fragments six inches in diameter. They are lighter in color than the matrix, and shew more distinctly on worn surfaces, especially when wet, than in fresh fractures.

From the above mentioned cove, three miles north of Poplar Lodge, the trap occupies the shore to a bay seven miles farther on. At the bottom of this bay a green slaty rock, supposed to be Huronian, makes its appearance, and is followed by quartzite, which may belong to the same series. The quartzite is sometimes interstratified with irregular beds of greenish chloritic and dioritic slates, and broad bands of a red granitic rock. The strike in this neighbourhood varies from about east to south-east, and the dip is vertical. For two or three miles south of Livingstone's Point, the rocks are of a gray gneissoid character, and are often cut by granite veins, running in different directions. Livingstone's Point, which is five miles long and from one to two miles wide, is composed of trap, rising to the height of 200 or 250 feet on the north side.

The rock, both of the islands and the main shore in the eastern part of Humboldt's Bay is gneiss, mostly fine-grained and compact. On a small Gneiss. island two and a-half miles south-west of the mouth of the O-na-ma-ni-sagi River, which enters the bottom of the bay, the gneiss dips northward at an angle of about 80° , and is composed of whitish quartz and feldspar, with black mica so arranged as to give the rock a schistose appearance. It is cut by a great number of branching and reticulating veins, varying from half-an-inch to one foot in thickness, and belonging to three distinct sets, Granite veins. the newer cutting those of older date. They are composed of red feldspar, white quartz and black mica. The newest set is coarsely crystalline, and contains but little mica; the oldest is the least crystalline, and contains mica in sufficient quantity to give it a dark color; while the second set is intermediate between them in both respects. On an island lying one mile west of the mouth of the O-na-ma-ni-sagi River, regularly stratified gneiss, in which hard slaty micaceous beds predominate, dips N. 14° E. (mag.) $< 75^{\circ}$, and rests upon a massive granitic rock. Thin, somewhat granular quartz layers or veins in the micaceous gneiss, on the west end of this island, carry copper pyrites. A few trap dykes cut the gneiss on some of the islands in the eastern part of this bay, their courses being between north and north-west. The largest one observed is about fifty feet thick. Dykes are rare on the shores of Lake Nipigon, only a few besides those in this locality having been observed. Along the north side of Humboldt's Bay the gneiss is overlaid by trap, which appears to occupy a considerable area in this neighbourhood.

Both the southern and northern extremities of the South Peninsula of

Ombabika.

Ombabika are composed of trap, the central portion being occupied by reddish coarsely crystalline granite or granitoid gneiss, with trap on some of the points and islands on the west side. Sandstone of a light gray color, rather fine-grained, hard and quartzose, occurs on the shore in three or four places between five and six miles south of the entrance to Ombabika Bay. It flanks the granite, and strikes northward with the shore, dipping eastward at an angle of 15° in one place, and at another westward into the lake, at an angle of 80° . Trap, in the form either of beds or great dykes, is associated with it.

Ombabika Bay is nearly twenty miles long in a north-westerly direction. Viewed from the opposite shore, the country all along its north-eastern side, appears level and covered with green wood. Gneiss occurs near the mouth of the Ombabika River, and on a low islet about a mile north-west of it, and again on a point eight and a-half miles north-west of the river. In all of these localities it is intersected with small granitic veins, and at the one last mentioned, shows on the surface very distinctly the outlines of angular pieces of syenite imbedded in the mass.

Ombabika
River.

In ascending the Ombabika River, Mr. McKellar made three portages around rapids or chutes of about ten, thirty and twenty-five feet fall, respectively; the last being about two miles in a straight line from the lake. Above this, the Indians informed him that no more portages occur for a long distance, and that the river passes through a lake lying seven or eight miles from its mouth in an easterly direction. The Indians all agree in describing the Ombabika River as flowing through a level country. It is said to rise in a lake three miles long, from which a stream also flows into the Albany River. From the mouth to the third fall the banks are from forty to eighty feet high, the lower portion being a calcareous blue clay, and the upper a mixture of sand and clay; while above this fall the surface of the country appears to maintain the same general level as below it, the banks only rising from ten to twenty feet over the river. The soil is excellent, being a dark-colored crumbling loam, free from boulders, and supporting a thick growth of tall, but not large spruce, balsam, tamarac, poplar and white birch trees. The rocks at the third fall are gneiss, with beds of a white granular quartz holding occasional scales of mica and crystals of iron pyrites. The portage is 390 paces long, and appears to be much used by the Indians. At the lower end the gneiss dips S. 40° W. (mag.) $<$ about 45° , and at the upper, where the bedding is very distinctly marked, S. 30° W. (mag.) $<$ about 60° .

The north peninsula of Ombabika, about twelve miles long, appears to be composed entirely of trap. Between this peninsula and Meeting Point, the country north of the lake seems to be all trap, rising in hills, sometimes 300 or 400 feet high, while some points on the lake shore consist of gneiss,

having generally a north-western strike. At one place, a short distance east of Meeting Point, the rock consists of epidosite, beautifully banded with shades of a darker and lighter green. In the same neighborhood a fine-grained variety of the trap is cut by small veins of thomsonite. Lake Nipigon.

West Side.—Starting again at Flat Rock Portage, the fixed rocks of the whole shore, and of the islands, as far as they came under our observation, consist of the black or dark greenish-gray trap, with a few exceptions, which will presently be described. The trap is generally crystalline, coarse-grained massive and columnar, and contains, in addition to the feldspathic and augitic minerals, magnetic iron and iron pyrites. Columnar trap. Under the influence of the weather, much of it becomes friable, and crumbles into gravel-like pieces, and eventually into soil. The process is no doubt aided by the decomposition of the pyrites, which is present, often in considerable quantities. This circumstance, and the columnar character of the trap, account for the peculiar effects arising from its denudation, producing an irregular and generally rocky coast-line, and many islands, with deep water around them, combined with good soil on the land. The trap is so strongly magnetic as to render the compass generally unreliable, and often totally unserviceable in its neighborhood. The coarse-grained varieties were observed to be more strongly magnetic than those of a finer and more compact character. When not strongly affected by local attraction, the variation of the magnetic needle ranged from 2° to 6° east of the true meridian. Where the bedding is distinct the surfaces often present reticulations resembling those formed in mud left by the drying-up of pools. These are marked, either by a difference in the color or in the character of the rock, causing them to weather out more rapidly than the rest of the mass. Distinctly marked stratification is, however, of exceptional occurrence, so that we were unable to determine the general structure and arrangement of the rocks throughout this great trap region. The first place at which well-marked bedding was noticed occurs on the west side of Long Point, where, at about three miles south of the extremity, the beds, which are from one to four feet thick, and exhibit the reticulating crack-marks, dip westward into the lake at an angle of about 70° . On a small islet close to the shore at this locality, numerous small veins following the joints in the trap, are filled with flesh-coloured thomsonite.

On the east shore of Black Sturgeon Bay, from the commencement of the narrow arm leading to the portage, for a distance of about two miles, the trap is interstratified with beds of argillite, felsite and sandstone, all on edge, and running in a northerly direction. These rocks appear along the margin of the lake, at the foot of Tchiatang's Bluff, 400 or 500 feet high, which runs for four miles along the south-east side of this bay; but their relation to the great mass of trap constituting this bluff was not

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determined. Some of the felsite beds are soft greenish and earthy ; others harder and schistose. The argillite is hard dark colored and compact, with a conchoidal fracture ; while the sandstones are light-colored and soft. One bed of the latter, of a very light greenish-gray color, is composed of fine silicious and argillaceous particles, with scattered grains of translucent quartz. High bluffs of trap continue down the east side of the arm towards the north-west extremity of Black Sturgeon Lake. Under these cliffs, at a distance of half a mile from the open bay, there is a band of light-gray tender harsh-grained sandstones, about 100 feet thick, dipping S. 80° W. (mag.) $< 50^{\circ}$, which appears to come between great masses of the coarse crystalline trap. Two miles further south, or about a quarter of a mile north of the extremity of Black Sturgeon Lake, beds of a coarse light-gray sandstone, holding occasional pebbles, mostly of white quartz, are found lying against the side of a hill of gray splintery schistose felsite. The sandstone dips south-westward at an angle of about 40° , while the felsite dips in the opposite direction, with an inclination of about 60° . At the point on the south-west side of the Narrows, at the entrance to Chief's Bay, the trap is in beds from one to five feet thick, dipping north-eastward into the lake at an angle of about 40° .

Limestone.

On the opposite side of the Narrows, which are half a mile wide, the trap is overlaid by compact argillaceous magnesian limestone, with a conchoidal fracture, dipping S. 25° W. (mag.) $< 5^{\circ}$. The beds are from three inches to two feet and a-half in thickness, and present different shades of a grayish and olive-green color. Although the section exposed does not appear to exceed ten feet in thickness, so regular and slight is the dip that these rocks extend for a quarter of a mile along the shore, and are seen along a brook to the north-westward, and in the bottom of the lake in front. Small pear-shaped bodies, about the size of peas, weather out on the surfaces of some of the beds, but they show no organic structure, either outwardly, or in sections examined under the microscope. The same olive-green limestone occurs again on the north-east shore of Chief's Bay, about two miles from the Narrows. The beds are from six inches to two feet thick, and dip S. 40° W. (mag.) $< 8^{\circ}$. A section of six or eight feet is exposed, and the strata are underlaid conformably by beds of fine-grained compact black trap, shewing crack-marks on the surface. Similar trap is met with, in thin beds, only from six inches to one foot in thickness, at the foot of the first rapid on the Poshkokagan River, about three miles south of its mouth, which is at the southern extremity of Chief's Bay. The dip is here N. 60° W. (mag.) $< 5^{\circ}$. On the west side of the river, at this rapid, a bank, composed of gravel, sand, loam, clay and boulders, rises to the height of sixty or seventy feet. On its side, and in the bed of the stream, are many angular fragments, some

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of them of large size, of gray, red, darker and lighter green and in sandstone and indurated marl, and others of a soft white marly limestone which, my Indian guide informed me, occurs *in situ* on this river about thirteen miles, in a straight line, south of its mouth. The man pointed out to me a spot on the west side of the Poshkokagan, half a mile below the first rapid, at which a spring of brackish water issues from the mud, when the river is low.

A small island, only a few chains in length, lying at the bottom of Grand Bay, and about one mile north of Tchiatang's Bluff, is composed of coarse light gray gneiss, consisting of quartz, feldspar, and a little mica, with a few thin interrupted bands of mica-schist. The stratification is vertical, and runs about N. 85° W. (mag.) The trap nearest to this island is very fine-grained, tough and compact. This was the only exposure of gneiss observed around the whole of the southern and western shores of the lake, as far as Wabinoosh Point; unless, indeed, some patches of white-weathering rock, which were observed behind the shore, near the south side of West Bay, should prove to be Laurentian. The gneiss begins on Wabinoosh Point, at one mile north of the bay of the same name, and continues in a low narrow strip along the shore, for a distance of one mile and three-quarters, and is overlaid by the trap, which rises to cliffs 300 feet high, immediately above it. The rock is of a light color, and composed of white quartz, feldspar, and black mica, with small spots of epidote. Mica-schist and coarse red feldspar-rock are associated with it in one place. The general dip is S. 15° E. (mag.) < 65°. Gneiss was again met with on several small low points and islands, for three miles along the shore opposite Windigo's Islands, in the north-western part of the lake. It is of the same character as the last, and like it, contains occasionally, patches of mica-schist and of coarse red crystalline feldspar. In the distance mentioned, the bedding appears to have a synclinal dip, dipping north at an angle of 30° in the south part, and south at an angle of 45° in the northern; being evenly stratified in both localities, but somewhat disturbed in the central part. The most northern of Windigo's Islands is composed of gneiss, the others of trap. The north shore of Windigo's Bay is low, and the country behind, level, with three or four conical hills rising from it, within sight of the lake. The most remarkable of these is the Sugar Loaf, about 300 feet high, and lying at a distance of two miles and a-half northward from the mouth of the Pickitigou River. This river was surveyed for a distance of four miles and a-half from the mouth. The only rock met with was a small hill of trap on the west side, at two miles from the lake. The high ground on Meeting Point, on the east side of Windigo's Bay, consists of trap, which is mostly fine-grained near the shore, while the islands at its extremity, and some of

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small points to the north-eastward, are composed of gneiss. The latter rock is mostly of a hard gray massive variety, made up of whitish quartz and feldspar, with black mica. The last mentioned mineral is abundant in some places, and the whole rock occasionally passes into mica-schist. In the more quartzose portions, epidote occurs in strings and disseminated particles. The dip is generally north-eastward. On the north point of an island three quarters of a mile west of the extremity of Meeting Point, there is an irregular vein of white quartz, a few inches wide, running N. 50° E., and carrying specular iron and crystals of green epidote.

Feldspar-porphry.

The lake shore, and the islands from the Hudson Bay Company's farm at Nipigon House, to English Bay, a distance of three miles, are occupied by a brick-red porphyry, composed of crystalline red orthoclase feldspar, with grains of translucent quartz, enclosing finer stratified patches of the same color, and others of white quartz. It also holds spots of a soft green earthy mineral, and small cavities lined with crystals of feldspar. A point on the west side of Jackfish Island is also composed of this red rock. In some places it is broken into regularly shaped blocks of a convenient size for building.

Sandstone.

The shore, just below Nipigon House, is covered with angular blocks and slabs of very evenly bedded, rather fine, free-grained sandstone. In one of the fields, just south of the house, a considerable number of large angular masses of the same rock occurs. It is mostly of a rich, dark reddish-brown color, and being easily worked, would make a fine building stone. Some of it splits beautifully into very even and parallel-surfaced slabs, which would form excellent flagstones. These thinly bedded portions consist of alternating reddish and grayish layers, each only a few inches thick. We were informed that an excavation, which had once been made near the shore at this place, shewed some beds of the sandstone lying horizontally, *in situ*. Angular fragments of coarse gray sandstone with ripple-marked surfaces, and of a soft friable ashy gray argillaceous rock are numerous at Nipigon House.

Dog Island, lying in front of Nipigon House, and separated from the mainland by a channel a quarter of a mile wide, is composed of fine-grained black trap, apparently lying almost horizontally. On the mainland opposite the south end of Dog Island, fine-grained black trap also occurs, and dips S. 20° E. (mag.) 5°. Mount Royal, on Jackfish Island, is about 400 feet high, and consists of trap, which is fine-grained near the junction of the red porphyry, on the west side of the island. The stratification appears to be nearly horizontal, and the worn surfaces of some beds on the shore exhibit closely reticulating crack-marks, very conspicuously. The most northern island in English Bay, and the point between this bay and Wabinoash Bay, consist of the black trap. The red porphyry, and also

the sandstone of this locality, would therefore appear to be overlaid to the south, east and north by this rock.

A survey was made of the lower Wabinoſh Lake, and of the river connecting it with the head of the bay of the ſame name. The trap hills around Wabinoſh Bay, and the lake juſt mentioned, are from 400 to 500 feet high; while the Inner Barn, with its ſides of columnar trap, riſes like a great caſtle, in the middle of the bay, to a height of upwards of 600 feet, and appears to be the higheſt point around Lake Nipigon. The Outer Barn, four miles eaſt of the others, and having much the ſame appearance, we found, by means of the aneroid barometer, to be 574 feet in height.

Wabinoſh
Lake.

Judging from the deſcriptions and ſketch-plans obtained from the Indians, the country drained by the ſtreams from the ſouth-weſtward, flowing into Lake Nipigon, and the region for a conſiderable diſtance weſt of the Black Sturgeon River, is occupied principally by the black trap and red marls or ſandſtones of the Upper Copper-bearing ſeries. According to the ſame ſources of information, the black trap, interrupted by occaſional areas of Laurentian rock, extends to a ſtill greater diſtance weſtward from Lake Nipigon, and is followed by flat-lying liſtſtones. From the deſcription by Dr. Bigsby (*Jour. Geol. Soc. Lon.*), I ſhould judge that the high iſlands which he obſerved in Whitefiſh Lake, between Lonely Lake and the Lake of the Woods, conſiſt of columnar trap, like that of Nipigon. I underſtand that Mr. McTaviſh, of the Hudson Bay Company, has obſerved liſtſtone with abundance of foſſils around Lonely Lake, on the Engliſh River; and my Indian guide aſſured me that he had ſeen a rock, which, from his deſcription, I judged to be of the ſame character, oppoſite a Hudson Bay Company's poſt on the Kon-a-don-wen-gwak, or Sand Lake, on the Albany River; apparently in a poſition correſponding with the north-eaſtern extremity of the ſo-called "Lake St. Joſeph," of ſome maps. He alſo informed me that he had ſeen black trap, ſimilar to that of Lake Nipigon, on the Albany River, both above and below the place at which the liſtſtone occurs; and liſtſtone again below the lower locality of the trap, or between it and Martin's Falls. I learn from Mr. Geo. Barnſton, formerly of the Hudson Bay Company, that gneiß croſſes this river at Martin's Falls, below which the unaltered ſtrata, referred to by Sir John Richardſon, continue to the ſea. From the deſcriptions of the Indians, it would appear that a gray liſtſtone occurs along the upper part of the Ombabika River, which, as already ſtated, they deſcribe as flowing through a level country.

Geological
notes.

It would therefore ſeem that between Lake Superior and the palæozoic region around James's Bay, there is a complete break in the continuity of the Laurentian and Huronian range. A part of this interval is occupied

by Lake Nipigon and the surrounding country. The true age of the Upper Copper-bearing rocks of this region may perhaps be most easily determined by tracing them to their contact with the fossiliferous paleozoic strata to the north or north-west of Lake Nipigon.

Overlying trap. The trap rocks of Lake Nipigon, and the country between it and Lake Superior, probably belong, partly to the eleventh division of the list which I have given, on page 318, and partly to the crowning overflow. This may be regarded as the newest rock of the whole region, since no strata have yet been found lying upon it, either in the Nipigon district, or around Lake Superior; while, on the other hand, it is found resting in different places, upon almost all the other rocks of the country. The following list of those rocks with which the trap overflow has been seen in contact, recapitulates briefly a number of examples already mentioned:

Contacts.

1. Laurentian gneiss, at the Long and the One-mile Portage on the Nipigon River; on the north-east side of Black Sturgeon Lake; and at the numerous localities which have been mentioned in the northern part of Lake Nipigon, from Wabinoash Bay to Livingstone's Point.

2. Huronian slates in various places on the east side of Lake Nipigon, from Black Water River to Livingstone's Point; and also on what appear to be Huronian quartzites at the north-east side of Lake Maria.

3. Cherts, shales, etc., (2 and 3) of the lower portion of the Upper Copper-bearing rocks, south of the Kaminitiquia River, and along the coast of Lake Superior from this river to the boundary line.

4. Argillaceous sandstones (4) of the same group on Thunder Cape.

5. Dolomitic sandstones and conglomerates (5) of the same group on Wood's location.

6. Red argillaceous limestones on the east side of Nipigon Harbor, near Red Rock.

7. Red marls on the west side of Nipigon Harbor, and in the isolated hill which has been mentioned as occurring near Black Sturgeon River, on the portage from Nipigon Bay.

8. Red marls, shales and sandstones along the lower section of the Black Sturgeon River.

9. Flaggy arenaceous and silicious gray shales, a short distance west of Red Rock.

10. Brick-red quartziferous porphyry, and probably red and gray sandstone, at Nipigon House.

11. It is also found, apparently in contact, with the trap, sandstones, argillites, soft greenish and gray splintery shaly felsites, occurring from the east side of Black Sturgeon Bay, on Lake Nipigon, to the northern extremity of Black Sturgeon Lake.

12. Also, apparently, with the rocks of the eleventh division, in the

peninsula between Black Bay and the main body of Lake Superior, forming some of the higher points, such as The Paps.

SURFACE GEOLOGY.

Except in the Laurentian region around Dog Lake, the surface of the country examined does not generally present a rounded or mammillated appearance. This is owing to the fact that the greater part of the area is occupied by the Upper Copper-bearing rocks, which, being of unequal hardness, and with a stratification approximately horizontal, give rise, by denudation, to level tracts and vertical cliffs.

Glacial Striæ.—The glacial striæ belong to two sets, one running westward and the other southward. Around Lake Nipigon, the two sets often intersect each other, the one having a western course being the more recent. The following table gives a number of examples of the courses observed in different places, the directions being referred to the magnetic meridian. The variation averaged about 5° east of the true north.

	Older set.	Newer set.
1. Red River Road, 10½ miles from Thunder Bay.....	S. 25° E.	.....
2. do do 13 do do do	S. 25° E.	.....
3. do do 5 do do do	About W.	.....
4. Mining-lot H, township of McIntyre.....	S. 75° W.	.....
5. Kaminitiquia River at intersection of Red River Road.....	S. 75° W.	.....
6. South side of Dog Lake.....	S. 70° W.
7. Near north end of Lake Maria on the Nipigon River.....	About S.

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8. North-west side of McIntyre's Bay, near portage.....	S. 65° W.
9. Extremity of Long Point on east side of Grand Bay.....	S. 70° W.
10. Small island at the bottom of Grand Bay.....	S. 70° W.
11. Isd. on W. side Grand Bay 4½ miles N. of Tchiatang's Point....	S. 10° W.
12. Point do do 7 do do do	S. 75° W.
13. West side of entrance to Gull Bay.....	S. 80° W.
14. Rocking-stone Isd. between entrance to Gull Bay and West Bay.....	S. 80° W.
15. Small island in the same vicinity.....	S. 85° W.
16. Largest island in West Bay.....	S. 85° W.
17. North end of Dog Island, opposite Nipigon House.....	S. 80° W.
18. Point on west side of Jackfish Island.....	S. 80° W.
19. Shore opposite Windigo's Islands.....	S. 60° W.
20. W. side of Britannia Island, S. W. of Meeting Point.....	S. 30° W.
21. Extremity of Meeting Point.....	S. 75° W.
22. Island two miles W. of entrance to Ombabika Bay.....	S. 55° W.
23. Southern extremity of S. Peninsula of Ombabika.....	S. 13° E.
24. Point about two miles north of Poplar Lodge.....	S. 5° W.
25. Poplar Lodge Point.....	S. 10° W.
26. Point 3½ miles south of Poplar Lodge.....	S. 85° W.
27. Columbus Point.....	S. 45° W.

Ice grooves.

On the east side of the northern extremity of Lake Maria, the grooving is well seen in horizontal lines, up to a considerable height above the water, on the side of a perpendicular cliff facing west. Grooves were observed slanting, first downward, then upward, forming a regular curve, on the face of a vertical wall of trap on the west side of Grand Bay, Lake Nipigon. At one place in the same vicinity, where the grooves shoot up a very steep slope, rising out of the lake, they were observed to diverge in a fan-like form, from a depression in the surface of a rock. Around the point between English and Wabinoah Bays, where the shore is bold, and the water deep, the striæ run westward, up very steep inclinations, in some places approaching the perpendicular; in which cases the grooves are short, and the rock has a battered appearance. Occasionally the steep grooved surface has a curved form like that of a plough-share. The westward course of the more recent set of grooves will account for the greater general depth of the western side of Lake Nipigon as compared with the eastern; while the north and south bays of the southern side may have been eroded by the agencies which produced the southward set of grooves. The large angles at which the two sets of striæ often intersect each other, on even surfaces, is a fact worthy of note in regard to the question as to whether the grooves were produced by glaciers or icebergs.

Drift.

Drift.—Boulders and pebbles derived from the Upper Copper-bearing rocks of the peninsula between Black and Thunder Bays, have been strewn over the surface of the older formations in the country immediately west of the latter bay; just as the *debris* of the Lower and Middle Silurian rocks has been carried westward over the higher strata of the western peninsula of Ontario. On the west side of the Kaminitiquia, at the intersection of the Red River Road, boulders, with a small admixture of finer material, are thrown up in conspicuous ridges and hillocks at the base of the hills, which rise to the height of about 400 feet immediately above them. These accumulations appear to have formed the terminal moraines of glaciers proceeding from the valley of Strawberry Brook, directly opposite.

Around Lake Nipigon the materials of the drift have also evidently travelled westward. On the north side of Wabinoah Bay, great boulders from the low gneissic area already described, have been carried in this direction, and scattered upon the overlying trap. One of these, resting upon a hill-side on Wabinoah Point, a quarter of a mile back from the shore, measures twenty feet in diameter, and is distinctly seen as a white spot from the level of the lake, at a distance of seven miles. All along the north-west shore of the lake, from Wabinoah to Windigo's Bay, there are numerous boulders of fine-grained hard light-gray quartzose sandstone, broadly ribboned with lighter and darker shades of pink. Some of them

are rather coarser-grained than the average, and contain pebbles of white quartz, and more rarely of red jasper. These sandstone boulders have probably been brought up from the bed of the lake, between this part of the shore and the islands to the eastward. Laurentian boulders were seldom seen around Lake Nipigon, except in the vicinity of the same rock *in situ*. Small rounded fragments of light cream-gray limestone, containing a species of *Pentamerus*, were occasionally found on the east side of the lake; and a somewhat angular mass of the same rock, measuring nearly three feet in diameter by a foot and a-half in thickness, was met with on Gneiss Island, at the bottom of Grand Bay. The limestone of this block was very pure, soft, and somewhat porous, and full of rather imperfect fossils, the commonest being a *Pentamerus*, which, Mr. Billings says, is very like some of the forms of *P. galeatus*, but probably a new species. Mr. Billings also recognises amongst these fossils a species of *Favosites*, with small tubes about half a line in diameter, a *Rhynchonella*, and a species of *Zaphrentis*, about one inch in length. He says: "These fossils are not sufficient to determine the age of the deposit from which they were derived, except in a general way. It is not Lower Silurian, and is not so recent as the Middle Devonian. I think it about the age of the Niagara formation." I may here mention that, in 1846, Sir William Logan collected, on the shore of Lake Superior, east of Pic Island, a number of fossils in loose pieces of light yellowish-brown limestone, and some in gray and yellow chert. These fossils have recently been examined by Mr. Billings, who says that they "belong to the genera *Favosites*, *Zaphrentis*, *Streptorhynchus*, *Atrypa*, *Orthis*, *Pterinea*, *Dalmanites* and *Leperditia*. They are Devonian. The only determinable species is *Orthis lowensis* (Hall), a species characteristic of the Hamilton group in Iowa. It occurs also, far north, on Laird River, and on Snake Island in Lake Winnipegosis, in the same kind of rock,"—a light yellowish-brown limestone. Mr. Thomas Herrick, P.L.S., informed me that he crossed a patch of flat-lying fossiliferous limestone, some two or three miles in breadth, on the Pic River, where his line intersects it, at about thirty-two miles, in a straight line, northward from its mouth. Fragments of olive-green limestone, similar to that described as occurring in place on Cook's Point and the north-east side of Chief's Bay, on Lake Nipigon, were found on Champlain Point and Britannia Island, in the same lake, and on the shore of Lake Superior, near Sucker Brook.

Ridges and Terraces.—On the south side of Dog Lake, terraces of sand and gravel, from fifteen to twenty feet high, are seen in some places close to the present beach. The high ridge crossed by the portage from Little to Great Dog Lake is covered with fine sand. On the north side of the Kaminitiquia, beginning opposite the mouth of the Whitefish River, a

regular terrace, apparently of gravel and sand, burnt bare of vegetation, and about forty feet high, runs eastward, close to the river, for a distance of about two miles. A ridge of boulder-drift about forty feet high, crossing the Nipigon at the foot of Lake Helen, near Red Rock, and another, sixty or seventy feet high, at the first rapid on the Poshkokagan River, have been already mentioned. A ridge of sand, with boulders and stones, rising to a height of thirty or forty feet out of a level sandy plain, and running in a westerly direction, crosses the Kabitotiquia River about six miles, in a straight line, south of its mouth. It occasions a small rapid, seventy paces long, over trap boulders, with a fall of four and one-half feet. This is the only rapid from the mouth of the river to a long distance above this point. At Champlain Point, the bank of the lake is about twenty feet high, and composed of loam and gravel, with boulders in the lower part. Some of the latter are Laurentian, which are rarely seen in this part of the lake. A terrace of gravel and sand, rising to the height of 150 or 200 feet above the level of Lake Nipigon, runs for a distance of about two miles along the shore between Echo Rock and West Bay. Having been denuded of timber by some recent fire, these terraces had a very conspicuous appearance as viewed from the lake. A terrace about sixty feet high, composed of very fine white sand, runs for two miles along the shore, northward from the mouth of the Kawabatongwa, and has given rise to the Indian name, which means White Sand River.

Ice movements.

Effects of Recent Ice.—The effects of the spring shoves of lake ice are observable in many places around Lake Nipigon, as well as Lake Superior, in the form of rows of boulders and shingle piled upon the beach, or just between it and the vegetation behind. Where the beach is soft it is often found that each boulder has ploughed a furrow from the margin of the water to its resting place. The rows of shoved boulders were noticed particularly along the west side of Grand Bay, and between West Bay and the entrance to Gull Bay. Very large boulders of trap have been piled, apparently by recent ice, upon the small islands in the latter bay.

None of the abrading effects produced by river-ice during the spring-floods, on the banks, trees and bushes, such as are seen along many of the rivers of Gaspé and the maritime provinces, were observed on any of the tributaries of Lake Nipigon, or upon the Nipigon or Black Sturgeon Rivers.

Sand and Clay Deposits ; Soil.—In the hilly country around Thunder Bay and Dog Lake, where any soil exists, it is usually a yellowish-brown gravelly loam, with boulders. The sandy tract, underlaid by laminated buff, drab and bluish clay, along the lower reach of the Kaminitiquia River, has been already described, and the existence of nodules in this clay is referred to in the *Geology of Canada*, page 905. Along the greater part

of this stretch, the banks, on alternate sides, are from forty to fifty feet high, the upper half being yellowish sand, and the lower clay. The land is low about the mouth of the river, and gradually dips under the lake. The surface is here sandy, but the clay is said to be found at the depth of a few feet, in digging wells, and a similar condition, no doubt, extends below the lake.

In the valley of the upper reach of the Kaminitiquia, a stiff red clay begins at four miles below the head of Little Dog Lake, and extends southward to the junction of the Mattawa. From this point it is found along the Red River Road, to a distance of about five miles eastward from the Kaminitiquia, gradually rising to an elevation of 400 or 500 feet above its level. On the west side of the river, it is also found on the flanks of the hills above the boulder deposits already described, to the height of about 200 feet above the river, and it is said to extend westward some distance up the valley of the Mattawa.

There is much good land along the north-west side of Black Bay. The country is level and sandy from the head of this bay to Nipigon Bay, and a sandy soil extends up the valley of the Black Sturgeon River. The sand, which is very fine, appears to be underlaid everywhere in these parts by clay.

In the Nipigon country the largest tract of good land appears to lie on the south-western side of the lake. From the Nonwatan River, northward to the Pajitchigamo, a distance of fifty miles, the country is comparatively level, and the soil generally fertile; but we could not ascertain, from our own explorations, how far westward this tract extends. The Indians and others, however, represent it as continuing nearly to the Winnipeg River, and becoming more generally level in receding from Lake Nipigon. Some of the peninsulas in Lake Nipigon, within the above distance, are hilly, but the soil is generally good, even on these, consisting of a brownish loam, sufficiently tenacious, when moist, to retain its form after having been pressed in the hand. The rivers entering this part of Lake Nipigon, as far as examined, were found to flow, with tortuous courses, between muddy banks of clay, overspread with fine sand. The clay, as seen in the banks, generally appears sandy, from having become mixed with the overlying deposit, but when clean sections are obtained, it is usually found to be stiff, tenacious and free from grit. On the higher levels the sand is often coarser and interstratified with layers of gravel.

There is a considerable area of good land around the bottom of South and McIntyre's Bays, and on the peninsulas east of the latter bay and Sull Bay. From the mouth to the first rapid on the Poshkokagan, the sandy banks of the river are from twenty to thirty feet high. The Kaministiquia River is so crooked that by following its windings from the mouth

Sand and clay. to the portage leading to Chief's Bay, the distance was estimated to be fully thirty miles, although it is only nine miles in a straight course. The water is deep, and the current slack throughout, except at the slight rapid previously mentioned. In ascending the river the banks rise gradually in height, increasing from a few inches above the level of the water, at the mouth, to five and ten feet, in the above distance. For the first five miles there is a wide open margin on each side of the river, covered with grass. On both sides, the country is level and the soil sandy, supporting a growth of grass and bushes, the timber having been all burnt off by repeated fires within the last few years. The land is free from stones, and very little labor would be necessary to make it ready for the plough.

From the Kawabatongwa River to the Pickitigouching, the country is low, near the lake, and a level tract extends northward to an unknown distance from Windigo's Bay. It is believed that in this direction a large area is overspread with light-colored clay. During the spring freshets the waters of the Pickitigouching are said to be quite milky from the clay which they hold in suspension, and hence the Indian name of this stream, which signifies the Muddy River.

It has been already mentioned that the country is level, and the soil good, all along the north-east side of Ombabika Bay, and at least as far back from it, in a north-easterly direction, as the eye can reach. Below the first rapid on the Ombabika River, from twenty to thirty feet of the underlying clay are seen above the water; the upper part of the banks, which are from forty to eighty feet high, being composed of sand, sometimes interstratified with clay. The clay, which is in horizontal beds, is free from pebbles or grit, light blue in color, calcareous, sticky and plastic. Above the third portage the river does not cut so deeply into these deposits, the banks being only from ten to twenty feet high. The soil in this region is a dark-colored crumbling loam.

On the south side of the Sturgeon, or Poplar Lodge River, as far as it was examined, the banks, consisting of fine white sand, rise to the height of thirty or forty feet. An undulating sandy country extends for a mile or two to the southward of the river.

The beach sand around Lake Nipigon and Black Sturgeon Lake is often mixed with particles of magnetic iron, probably derived from the trap of the vicinity, but it did not appear to occur in any place in sufficient quantity to be of economic value. Particles of garnet were abundant in the sand in some places in the northern part of the lake.

Climate and Timber.—The climate of the Nipigon country appears to be as well suited for agriculture as that of the greater part of the province of Quebec. Farming has been successfully carried on, for a long time, by the Hudson Bay Company at Nipigon House. The timber around

Lake Nipigon is principally white spruce, white birch, aspen and poplar, Forest trees.
 balsam-fir, tamarac and white cedar, with occasional trees of black ash,
 grey elm, red and white pine. In the month of February last, I had the
 honor of giving full details on these subjects, in evidence before the
 Committee of the House of Commons on Immigration and Agriculture, and
 I understand that they will be published with the report of the Minister
 of Agriculture.

ECONOMIC MINERALS.

The Upper Copper-bearing rocks, all the way from the boundary line to Mineral veins.
 Nipigon Bay, are cut by numerous metaliferous veins. These are so well
 described in the *Geology of Canada*, pages 74, 75 and 76, that in the
 present state of our knowledge, little of a general nature can be added.
 As there stated, the veinstones consist of quartz, which is usually either
 amethystine, or else white and granular, calc-spar, barytes, and variously
 colored fluor-spar; and where they cut the higher members of the series,
 zeolites and other minerals are also frequently present; while their metallic
 contents embrace "copper, lead, zinc and silver, with more rarely nickel,
 cobalt, arsenic, uranium and molybdenum." Sir William Logan says,
 (p. 74) "the indications which they present are such as to render it
 certain that many parts of the country characterised by them will, sooner
 or later, rise into importance as a mining region." It is stated on pages Gold.
 76 and 745, that a little gold had been met with in a vein on Prince's
 location. Since the *Geology of Canada* was written, Professor Chapman,
 in April, 1868, found the same metal in larger quantity in the ore of the
 Lead Hills location near Black Blay. With regard to this ore, he says:
 "Carefully conducted assays shew amounts of gold varying, per ton, from
 about 14 to 19 dwts., the mean of those already made giving 17 dwts. 12
 grs., with 2 oz. 2 dwts. of silver."

In reference to the course of the veins, Sir William Logan says (page 74):
 "As in the case of the dykes, the mineral veins belong to two systems,—
 one coincident with the range of the rock masses, and the other transverse
 to it. They are therefore parallel to the dykes,"—the one system being
 about N. and S., and the other varying from N.E. and S.W., to E. and W.;
 or, on an average, E.N.E. and W.S.W. It will be observed that these
 directions also correspond with those of the two sets of ice-grooves.

The additional information in regard to economical minerals obtained
 during our explorations will now be given under their respective heads.

Iron.—Reference has been made to the occurrence of a mixture of
 magnetic iron ore with insoluble matter, chiefly silicious, in the form of
 a thin-bedded deposit, apparently of considerable extent, and containing,

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ed, 37.73 per cent of metallic iron. Dr. Hunt says melted, but would require a large amount of lime. P. Savigny, P.L.S., of Toronto, has shown me magnetic iron ore, which, he says, occurs in large pieces from the shore of Thunder Bay, near Amethyst. A piece of pure botryoidal red hematite was given me, which has been found at Arrow Lake. Chief Manitoussais, of the same name, showed me some earthy red hematite, used by the Indians. He says it is found in abundance in a hill on the east shore. I have seen specimens of hard fine grained hematite which have come from the Red Paint River, and pieces of thin veins, which are reported to exist just behind the hills. Large quantities of specular iron were found in the red sandstone west-facing hills overlooking the Black Sturgeon River, and the same mineral has been referred to as a quartz vein on an island off Meeting Point. It was also found by McKellar in small veins, in several places on the north shore of Lake Huron, near the Saginaw Lodge and Sandy River. It has been already mentioned as iron in the beach-sands around Lake Nipigon and as in no place found in sufficient quantity to be of value. The Indians sometimes mistake the blacker and heavier hematite for iron ore, and might thus mislead explorers. A large vein was said to have been found last summer, on the north bank of Pigeon River, about two miles from the mouth. It was reported to have been discovered on Lake Nipigon and Whitefish Lake. On the north bank of Lake Huron, in three or four feet thick, running north-east and south-west, on 5th lot in the township of Paipoonge. It is composed of calc-spar and fluor-spar, with a little copper and galena. In the township of McIntyre, near the mouth of the Pigeon River, pieces of similar veinstone, with crystals scattered upon the surface, indicating the nature of the mineral from which they have been derived. A large vein of hematite, and also zinc blende, crosses the Paresseur River, at the intersection of the side-line between the townships of Paipoonge and McIntyre. Mr. Herrick, who surveyed this township, observed the same vein some miles to the south of the mouth of the Pigeon River, on the opposite side of the river, through the township. He gives its width as varying from 10 to 20 feet. It is supposed by explorers to be identical with the vein of the Algoma mine, which has been already mentioned as being on the north-west corner lot of Neebing. The

Wallbridge mine is on the west half of this lot, and here, a shaft, *Mineral veins.* said to be fifty feet deep, has been sunk on the same vein. Mineral veins of a similar character, and, for the most part, running in a direction approaching E.N.E., have been discovered in a considerable number of localities among the Upper Copper-bearing rocks in the township of McIntyre, and along the north shore of Thunder Bay, and thence to Black Bay. They are too numerous for separate description within the limits of this report, but their positions are shewn upon the accompanying map. The largest vein examined, occurring upon mining-lot M, has been already mentioned. It is composed of quartz, with a very little calc-spar, and is of a coarsely brecciated character, much of it consisting of a net-work of small veins; its total breadth is forty feet. Openings which have been made upon it where it is crossed by McIntyre's River, on this lot, do not appear to have brought to light any kind of ore. Its course is here N. 50° E. (mag.) with an underlie to the S.E. of about 10° from the perpendicular. Being harder than the sandstones and shales of the country, it forms a small ridge, which is rendered conspicuous by its white color. Mr. Macfarlane describes a vein having the same character, width and course on Shangoniah Island, in front of Wood's location, (*Can. Nat.*, Dec. 1869, p. 461.) A vein of about the same breadth, consisting of calc-spar and barytes, with some specks of galena, occurs on one of the small islands lying to the south-east of Pie Island, and was examined by two of our party. I was unable to visit the Lead Hills location, which is situated in the township of McTavish, at the distance of three or four miles west of *Lead m. loc.* the shore of Black Bay, and where a rich vein of lead ore occurs in a pale red indurated marl. In a report on this location, Professor Chapman says: "The vein consists of a gangue of quartz, with enclosed portions of wall-rock, and some heavy spar, etc., carrying a very strong lode of intermixed copper-pyrites and galena. The vein itself appears to average about ten feet in width; but, at present, it is to a great extent uncovered. The copper-pyrites and galena, although scattered more or less throughout the vein, run principally in a solid lode, of at least four feet in width. The course of the vein is about N. 65° E.; and so far as this can be determined in the present undeveloped state of the vein, the dip, or underlie, is toward the southwest, at an angle of about 80°." In one sample he found 8.10, and in another 11.62 per cent. of copper. One of these samples also yielded 47.56 per cent. of lead. Professor Chapman's discovery of gold and silver in this ore has been already referred to. During our stay at Fort William, a number of blocks of solid ore were brought from the location, some of which would weigh several hundred pounds. A sample broken off one of them yielded, by Mr. Broome's analysis, 88.85 per cent. of lead, and this, by cupellation, gave nearly one ounce of silver and

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ton of lead. Several other lead-bearing veins in this neighborhood. A quartz vein, about one considerable quantity of galena, has been noticed s, page 690, as cutting the granitic gneiss of ay.

like Nipigon, Mr. De La Ronde reports a vein, good specimens of galena on the Poplar Lodge at its mouth. On the west side of the lake an men of drusy white quartz, holding galena, which in a vein about four inches wide, running north river, below Cedar Lake; three and a half days

Nipigon House. He also said that an ore, description to be copper-pyrites, was found at pecks of galena were met with in a loose fragment of limestone at the first rapid on the Poshkokagan

of native copper occurring among some of the upper Copper-bearing series, so far as they are in the *Geology of Canada*, pages 71 and 75. are found cutting this series in the Thunder Bay as noticed in the preceding paragraph, also some of them require further description. A vein of Rock, but which I was unable to examine, is rare ore.

Nipigon, Mr. McKellar reports that the diorites lake shore, on each side of Poplar Lodge, are number of quartz veins, carrying copper-pyrites, purple ore and copper-glance; and he thinks may be discovered in this vicinity. Small quartz copper-pyrites, have been already mentioned as found in Humboldt's Bay. The Indians report two the other of a reddish color, as traversing a high but none of those of our party who visited the

been discovered near the Hudson Bay Compa- mouth of the Wabinoah River, but we did not a vein containing amethyst is reported to occur Wabinoah River, at a point lying one and a half from Nipigon House.

is now been discovered in the native state or in at least seven different localities in the Thunder in most cases belonging to the north and south

set. The silver-bearing vein of Prince's location is described at page 76 ^{Silver ore.} of the *Geology of Canada*.

Last summer Mr. Macfarlane, agent of the Montreal Mining Company, obtained a quantity of silver ore from a vein on the Jarvis location. The same gentleman has fully described the silver-bearing vein of Wood's location in the *Canadian Naturalist*, 1868-70. The portion of the vein at present worked is upon Silver Islet, about one mile from the main shore of Thunder Cape. "It has a width of about twenty feet on the north side of the island, and to the southward divides into two branches, each seven or eight feet wide. The course of the vein is N. 32° to 35° W., and it dips to the eastward at an angle of about 8°." The ore is a mixture of native silver and silver-glance in a gangue consisting mainly of calc-spar and quartz, but holding also small quantities of galena, blende, iron and copper pyrites, graphite, cobalt-bloom, nickel-green, and a mineral containing arsenic, nickel and silver, which Mr. Macfarlane thinks may be a new species. The thickness of the rich part of the vein varies from a few inches to two feet, and it keeps to the east or hanging side of the vein." Up to the month of April of the present year, the value of the silver taken from the crop of the lode on the islet, or rather in the shallow water beside it, since its discovery in the summer of 1868, is supposed to amount to about \$25,000.

Wood's
location.

The lode at the Thunder Bay silver-mine, which has been referred to on page 326, consists of a network of small quartz veins, occupying a breadth of six or seven feet, and runs N. 34° E., with a slight underlie to the north-westward. Two shafts have been sunk upon it, each to the depth of about seventy feet. Between them, part of the lode consists of a vein stone of white granular quartz, about one foot thick, and in this most of the silver has hitherto been found. It occurs principally in the form of irregular branching filaments of the native metal, disseminated in the quartz in isolated bunches, in which the silver often forms more than ten per cent of the mass. One of these bunches, which was removed during our visit to the mine, weighed upwards of one hundred pounds. Silver-glance is also present in small quantities; the largest piece of this mineral which I saw would weigh about two ounces. The silver appeared to be most abundant in the upper fifteen feet, where the wall-rock, as mentioned on page 326, differs from that farther down. In the lower part of the mine silver-glance only has been found.

Thunder Bay
Mine.

The workings at the Shuniah mine, two miles west of the last, being full of water, could not be examined; but from the description of Professor Chapman, it appears that the conditions here are similar to those at the Thunder Bay mine, except that the vein runs nearly east and west.

At the Silver Lake location, about four miles north of the head of

Thunder Bay, the silver occurs as small grains, in the native state, with dark colored blende, in a vein of quartz. Another locality of silver is on McKellar's Island, one of the small rocky group south-east of Pie Island. Here the metal occurs with blende, as in the last locality, but the veinstone is mostly coarse calc-spar.

Gold.—The existence of gold, in a vein on Prince's location, is mentioned in the *Geology of Canada*, pages 76, 517 and 745, and some facts regard to its occurrence in a vein on the Lead Hill's location are given on page 357, of the present report.

Manganese.—Many of the boulders and pebbles uncovered, in making the Red River Road, about half way from Thunder Bay to the Kaminitiquia, are coated with black oxide of manganese.

Salt.—The brine-spring at the head of the first rapid on the north branch of the upper section of the Black Sturgeon, is described on page 335, and another has been mentioned as occurring half a mile below the first rapid on the Peshkokagan. My Indian guide informed me that a third was to be found near a small clear-water brook on the west side of Gull Bay, about a mile north of the mouth of the Kobitotiquia River. A handful of salt was obtained by boiling down about two quarts of the water of the first mentioned spring, but having afterwards become accidentally wet, the greater part of it was dissolved away, so that any analysis of what remained would be of no value.

Limestone.—Rock fit for burning into lime can probably be obtained among the beds of division 8, page 319, near the eastern line of Wood's cation, as well as from the calcareous strata on the east side of Nipigon Harbor; and perhaps also among the dolomite bands of the lower group, which have been described as occurring at the head of Thunder Bay, near the Thunder Bay silver-mines, and in the southern part of the township of McIntyre. The calcareous spar of some of the larger veins on the coast and islands between Pigeon River and Fort William may also prove valuable for the same purpose.

The specimens of the limestone from the north-east shore of the Chief's Bay, Lake Nipigon, which have been analysed by Mr. Broome, contain 8.5 per cent of insoluble silicious clay, which is probably in so large a proportion as to prevent the rock, when calcined, from forming, by itself, good cement. The soluble part is a magnesian carbonate of lime, of which one quarter is carbonate of magnesia. In a specimen from the similar rocks at Cook's Point, the insoluble clayey portion equalled only 29.6 per cent., and, as in the other case, one fourth of the soluble part consisted of carbonate of magnesia.

Brick Clay.—The stiff red clay which is so largely developed in the valley of the second reach of the Kaminitiquia River would probably make

REPORT OF MR. ROBERT BELL

very good common bricks. It is free from lime, but holds mu is therefore fusible. The lighter colored stratified clay of the is also apparently suited for the same purpose, as well as the which have been described as occurring in the valleys of most o entering Lake Nipigon.

Building Stone.—Among the stones most suitable for buildir met with in the region explored, may be mentioned the sandston in the peninsula between Thunder and Black Bays, along the of the Black Sturgeon River, east and south of Black Sturge Lake Nipigon, at Nipigon House, and on the southern p Ombabika; the limestone of Chief's Bay and Cook's Point; t porphyry to be found along the shore from Nipigon House to E and some varieties of the common dark trap, in various parts of

Roofing Tiles.—The hard dark colored shales of the low the Kaminitiquia are supposed by some to be fit for roofin but owing to their want of strength, and their imperfect cleava, but poorly adapted to such a use. On the east shore of Lal about three miles north of the Poplar Lodge River, Mr. McKel a band of dark colored slate with very perfect vertical cleavag thinks might answer for a roofing material.

RAILWAY ROUTE AND COLONIZATION.

In the special report on the practicability of a railway through country, which I had the honor of addressing to you on February last, a general description was given of the route w covered, and its advantages. Our map of the district having piled since that time, I am now enabled to indicate this route crosses the Nipigon at the outlet of Lake Helen, where the rive and the banks, consisting of boulder-drift, are from thirty i high. From this intersection it follows down the western side Harbor to a point about three and one-half miles south of where it turns westward through the level pass leading to Blac River. This river would be crossed at some point below Eahq Lake. Continuing north-westward, the route could pass eit west of Pike and Cyclas Lakes, or between them. Further o cross the Poshkokagan and the Kabitotiquia not far from Chie a very moderate elevation above Lake Nipigon. Between the la and the valley of the Gull River the country is level. The ge in the above distance—about 100 miles—is very slight; Lal according to the observations which I have given in a previous

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only a little more than 800 feet above Lake Superior; while the route there appear to be no difficult local grades. Besides the rapids to be crossed, the only obstruction which I observed is a small bar on the west side of Nipigon Harbor, just before turning west of the Black Sturgeon River. This consists of a cliff of red marl, rising from the margin of the lake. The water at its base is shallow, some of the stones rising above the surface, and sufficient to form an embankment could be easily dislodged from the narrow trap above. The whole length is only from fifty to one hundred feet.

The route for a railway may possibly be found by following up the valley of the Nipigon River, and the valley of Portage Brook, and then turning to the Black Sturgeon River in the neighborhood of Keshewau Lake.

The immediate purpose of colonizing the shores of Lake Nipigon might be constructed from Camp Alexander on the Nipigon River to South Bay on the lake, the distance being not much over 100 miles.

From this point, vessels on the lake would have access to 80 miles of coast-line, exclusive of the islands, many of which are small.

I have the honor to be,

Sir,

Your very obedient servant,

ROBERT BELL.

May 23rd, 1870.

REPORT
ON THE
COALS AND IRON ORES
OF
PICTOU COUNTY, NOVA SCOTIA,
BEING AN APPENDIX
TO
REPORTS ON THE PICTOU COAL FIELD,
BY
MR. EDWARD HARTLEY, F.G.S.,
MINING ENGINEER TO THE GEOLOGICAL SURVEY.

The following Report will furnish information concerning the economic value of the coals of Pictou County, Nova Scotia, together with a notice of some localities of iron ore likely to become of interest from their proximity to the Pictou coal-field; these deposits of iron ore having received examination during my field-work of the years 1868-69. It will be divided into three sections :—(I) Descriptions and analyses of Pictou coals; (II) Reports of practical trials of Pictou coals as steam and gas-producers, and for other purposes of the mechanic arts;—(III) Iron ores and their occurrence in Pictou County.

I.

DESCRIPTIONS AND ANALYSES OF PICTOU COALS.

A number of published papers and reports contain analyses of coals from the Pictou region; but with few exceptions, these publications are out of print, or otherwise inaccessible to the general public. In this section it is proposed to bring these scattered analyses together, supplementing them by a series made by myself during the spring of 1869, in the laboratory of Dr. T. Sterry Hunt, F.R.S., chemist to the Survey, and a few more careful determinations made still later, in Dr. Hunt's laboratory, by his assistant, Mr. Gordon Broome, F.G.S., Associate of the Royal School of Mines.

Classification of
analyses.

Analyses of coal may be divided into three classes ; (a) practical analyses in the large way, or the determination of the proximate constituents of the coal, that is, the moisture, volatile matters, coke and ash, by burning a large quantity ; (b) proximate analyses in the laboratory, or the result of the drying, coking, and incineration of a few grains in a small crucible ; and (c), ultimate analyses, being the careful determination of the ultimate elements of a coal or other fuel, such as carbon, hydrogen, oxygen and nitrogen ; the class (c) being, of course, the most satisfactory for calculations of the theoretical value of a coal.

Of the analyses now given, by far the greater number belong to the second class, (b) in which may be included all those made in the Survey laboratory, as the great expense and amount of time necessary for their completion has rendered both practical and ultimate analyses out of the question. Although far from satisfactory as accurate *measures* of the true value of coals, the crudest analyses enable us to form some idea of their character, and, in the absence of practical trials, furnish us with elements on which to base an approximate opinion as to what practical service they are best fitted to perform.

Method of
analysis.

The method of analysis pursued in the examination of the samples of coal obtained in the Pictou coal-field by myself, was somewhat as follows : Drying in a water-bath at a temperature of 212° Fahrenheit, to expel moisture ; heating to bright redness in a closed crucible to obtain the percentage of volatile combustible matter ; and finally incineration in an open crucible to obtain the amount of ash. In most cases two different samples of each coal were examined, one being coked by a sudden application of a high heat, to obtain the largest possible amount of volatile matter or *gas*, irrespective of its character, the quantity of coke being thus reduced to a minimum ; while in treating the second, the heat was applied with the greatest care, and raised very gradually, by which treatment the gases obtained are more highly carburetted, and in smaller quantity than when the heat is suddenly applied. In a few cases, determinations of sulphur have been made, but from this impurity the greater part of the coals now worked in the Pictou region are quite free. The general very light colour of their ashes attests their freedom, when properly selected, from sulphur in combination with iron, as *pyrites*, and among the coals examined, the ashes of but few contain an appreciable amount of sulphate of lime, being generally very silicious or sandy in the best coals, and therefore not inclined to form a clinker adherent to the grate-bars. No full analysis of the ashes of any of these coals has yet been made, so far as I am aware.

Theoretical
evaporative
powers.

The calculations of the *theoretical evaporative power* of the different coals analyzed, are based upon the fact, that in burning bituminous coals of the class under consideration, in an ordinary furnace, such as has always been

used for comparing their results in steam production with those of anthracites and other fuels, the combustion of the volatile matters of the coal does not, in most instances, produce more than enough heat to effect their volatilization, and therefore *theoretically*, the value of the coals for steam purposes, depends on their content of fixed carbon, or the carbon remaining in their coke when the coal is heated in close vessels.*

The calculation may be made as follows:—Let the weight of coke, less ash, in parts of one unit of coal—that is, the percentage of fixed carbon—be expressed by C ; the co-efficient of the heating power of carbon by c , and the co-efficient of the latent heat of steam at 212° F., by l ,—then:—

Method of calculation.

$$\frac{C \times c}{l} = x$$

x being the theoretical evaporative power of the coal, or the number of pounds of water which one pound of coal should evaporate from a temperature of 212° Fahrenheit, *theoretically*.

The values given to the co-efficients used, vary with different authors. To c —expressing the number of units of water which the combustion of one unit of pure carbon will raise 1° Fahrenheit—Regnault gives the value of 13,268, while by Dulong† it is given as 12,906.

Values of co-efficients.

To the co-efficient l , Regnault gives the value 965.7° ; while the experiments of Professor W. R. Johnson indicate for it a value as high as 1030° .‡

In my own calculations the values of Regnault have been used, although later experiments have shown a further modification,§ inasmuch as these values have been used in the Reports of the British Commissioners on the Naval Steam-Coal Enquiry,¶ with whose results a comparison will be most valuable, although in the American reports, (published before Regnault's

Official reports on coals.

*Practical experiments have already shown that North Country (or Newcastle) coals, burnt in proper furnaces calculated to prevent smoke, give a practical evaporative effect higher than the theoretical power based on this supposition, and I hope to be able at some future time to show a similar result with our coals; but as with an ordinary furnace, the method of calculation to be given approaches correctness, and more especially as I wish to compare the theoretical values of these coals with results obtained from experiments conducted some years since, I still, for the time, adhere to the old rule.

†Vide Comptes Rendus, tom. 7, page 871, et seq.

‡W. R. Johnson's Report on American Coals, 1844, p. 22.

§The late researches of Favre and Silbermann (*vide* Ann. Ch. Phys. (3) xxxiv, 357—xxxv. 15—xxxvii. 405.), and of Andrews (Phil. Mag. (3) xxxii. 321, 425), have slightly modified Regnault's values. For a full digest of their results, see the admirable article on FUELS, by Prof. B. H. Paul, in Watt's Chemical Dictionary, 1864, vol. II., p. 718, et seq.

¶Reports of Sir Henry T. De la Beche and Dr. Lyon Playfair to the Lords Commissioners of the Admiralty, on trials of coals, 1848 and 1852. See also Johnson's Coal Trade of British America, 1850, p. 78

exhaustive memoir* appeared,) the values of Dulong for c , and Johnson for l , have been adopted.

Value of theoretical results.

The results obtained by these different values do not differ as greatly from each other as they will be found to differ from actual results, and they are useful only in the absence of reliable practical trials. In coals of this class, *i.e.* bituminous coals with 25 % to 35 % of volatile matter, these theoretical indices are generally slightly higher than figures obtained from furnaces of low-pressure boilers where no special arrangements are made for "*smoke-consumption*"—as it is called, or more properly, smoke-prevention, for smoke once formed cannot be consumed.

Values from ultimate analyses.

In cases where ultimate analyses are to be obtained, the theoretical value of *all* the combustible matter in a coal may be obtained by the following formula :—

$$\left(\frac{C \times 18268}{965.7} \right) + \left(\frac{H - h \times 62470}{965.7} \right) = x$$

in which C represents the entire carbon content, both fixed and volatile, H the quantity of hydrogen in a unit of fuel, and h the quantity of hydrogen which will correspond to the oxygen in the coal; x expressing, as before, the number of pounds of water theoretically convertible into steam, from 212°, by one pound of coal, provided all the combustible constituents of the coal could be rendered available; or, in a word, the highest possible evaporative power of the fuel under any circumstances.

Expression of mechanical force.

The values of x , as used in the two preceding formulæ, or an evaporative value given by practical trial, may be converted into an expression of mechanical force by the formula :—

$$(Wn) \times 965.7 \times 782 = y,$$

in which W represents water, of which n pounds are evaporated by one pound of coal, (thus giving Wn the value of x in the preceding formulæ), and y representing the number of *foot-pounds* of work theoretically possible.†

*RECHAULT. *Relations des expériences entreprises * * * pour déterminer les principales lois et les données numériques qui entrent dans le calcul des machines à vapeur.* Paris, 1847. See also a translation of the portion on the latent heat of steam at different pressures, in the Works of the Cavendish Society, vol. I.

† This formula is deduced from the fact that n pounds of water, multiplied by 965.7°, or the co-efficient of the latent heat of steam at 212° F., indicates the number of pounds of water which would be raised 1° Fahrenheit by the combustion of one pound of coal. The number 782 arises from experiments on the mechanical force denoted by the elevation of temperature of a pound of water 1° F., that force being equal to 782 lbs. raised one foot high, according to the careful experiments of Mr. Joule on the friction of oil, water and mercury.—(Extract from Report of British Commissioners, from which the formula is taken.)

APPENDIX TO REPORTS ON THE PICTOU COAL FIELD

It should be distinctly understood that no calculations based on analyses can take the place of trials of the coals in the large retorts and gas-producers, for smelting, heating iron, or for any other use; for though, as a rule, these theoretical values furnish us a general idea of the use to which a coal is best fitted, it is of no occurrence that theory and practice differ greatly. For further information on practical values of fuel, I would refer the reader to the report of Prof. W. R. Johnson, and to the second section of this Report.

COALS OF THE WEST SIDE OF THE EAST RIVER

COALS FROM THE MAIN SEAM, ALBION MINES.

No favourable opportunity offered during my stay in this district for the examination of samples of the coal of the Main seam, which would enable me to satisfactorily separate the peculiar varieties of the different beds. I therefore reproduce the careful section prepared by Dr. D. D. Wells, which well illustrates the character of all the different descriptions of coals in the seam.*

This section was prepared from an examination of a column of the Main seam, extracted for the New York Industrial Exhibition by Mr. Henry Poole, then manager of the Albion mines.

SECTION OF MAIN SEAM, BY DR. J. W. DAWSON.

1. Roof shale; vegetable fragments and attached *Spirorbis* (in specimen).
2. Coal, with shaly bands.....
3. Coal, laminated; layers of mineral charcoal and bright coal; but ironstone balls in bottom.....
4. Coal, fine cubical and laminated; much mineral charcoal....
5. { Carbonaceous shale and ironstone, with layers of coarse (holing stone), remains of large fishes and coprolites. bed varies much in thickness.....
6. { Coal laminated and cubical; coarse towards bottom.....
7. Ironstone and carbonaceous shale in the coaly layers, and trunk *Lepidodendron*, *Ulodendron*, *Sigillaria*, etc., all prostrate..
8. Coal, laminated as in No. 6; line of ironstone balls in bottom.....
9. Coal, laminated and cubical; a few small ironstone balls; many vertical bundles of ferns in this and underlying coal.....
10. Ironstone and pyrites.....
11. Coal, laminated and cubical, as above.....
12. Coal, coarse layers of bituminous shale and pyrites.....
13. Coal, laminated, with a fossil trunk in pyrites.....
14. Coal, laminated and cubical, with layers of shale passing down into black slickensided underclay, with coaly bands

* Acadian Geology, second edition, pp. 331-32.

15. Underclay, to bottom of specimen.....	Ft. In. 0 10
Total.....	40 8
Vertical thickness.....	38 6

Coal of Main seam.

The general character of the coal from the Main seam is that of a highly bituminous caking coal, generally of a laminated structure, and showing much mineral charcoal on the planes of deposition. Although much impurity exists in the form of shale, ironstone, and arenaceous material carrying pyrites, these may be easily separated from the good coal in taking out the different floors of the seam. The coal raised is also carefully examined at the shutes, any refuse or shale being thrown aside before the coal is put into railway cars for shipment.

Specific gravity.

The specific gravity of this coal is stated by Dr. Dawson to be from "1.288 (which is that of the best coal extracted,) to 1.447 (which is that of the coarsest coal that has been worked)."

The mean specific gravity of six samples, taken from the top, middle and bottom of the seam, in the central part of the mines, is stated, on the same authority, as 1.325, which agrees exactly with the result of some trials made for the American Government, by Prof. W. R. Johnson, whose researches will receive attention in the second section of this Appendix.

The following, being an abstract of the statements of Dr. J. W. Dawson in his *Acadian Geology*, is extracted from Prof. How's late work on the *Mineralogy of Nova Scotia*, published by authority of the Provincial Government:—

"Numerous analyses were made by Dr. Dawson in 1854, shewing the character of the Albion Mines coal from different parts of the upper floor of the mine, and also the varieties existing throughout the whole thickness of their Main seam, in a series of assays of coals taken at distances of one foot in thickness. The general results were that the best coal was found on the N. W. side of the old workings, deterioration taking place at either extremity of the workings of the upper floor. In all parts of the mine the lower coal was inferior to that of the middle of the seam, and still more so to that of the upper part (above the "holing stone"), or "fall coal" of the miners. On the west, this fall coal disappeared, or was reduced to insignificant thickness. The assays made to show the variations in thickness of the whole seam were on coal taken at this western part. This valuable series of assays of the coal of this seam, so familiar to the world, is here given.

* *Acadian Geology*, p 333.

APPENDIX TO REPORTS ON THE PICTOU COAL FIE

*“ Assays of Samples taken at the distance of one foot in th
Main Seam of coal of the Albion Mines, Pictou, by Dr*

	Volatile by rapid coking.	Volatile by slow coking.	Fixed carb
1. Coal	26.0	19.9	63
2. do	27.8	24.1	63
3. do	27.4	25.7	60
4. do	27.2	25.0	65
5. do	25.8	25.1	64
6. do	25.2	24.9	62
7. do	27.4	22.0	68
8. do	26.8	22.9	66
9. do	27.0	23.9	61
10. Carbonaceous shale.....	16.4	15.9	26
11. Coal	28.8	25.8	59
12. do	27.2	26.4	62
13. do	27.6	24.7	62
14. do	26.6	23.9	61
15. do	26.8	23.1	65
16. do	28.8	24.9	62
17. do	30.4	26.0	65
18. do	26.0	26.1	63
19. do	26.0	25.0	66
20. do	26.8	22.7	63
21. Coarse coal.....	25.8	23.3	58
22. do	27.2	22.5	60
23. Coal.....	29.4	22.6	64
24. Coarse coal.....	25.8	22.4	67
25. do	25.8	23.1	60
26. do	27.8	21.9	64
27. Coal	27.0	24.3	65
28. do	25.6	22.4	65
29. do	25.8	22.7	62
30. do	27.2	23.1	67
31. do	32.6	22.4	66
32. Coarse coal.....	22.2	21.5	50

“ The coal above the “ holing stone” is not found at the part these coals were taken, as before explained. At the N.W. si workings it is three feet thick, and has this composition :—

Moisture (hygroscopic water).....
Volatile combustible matter.....
Fixed carbon.....
Ash.....

“ In these assays we have a most instructive and interesting
ments, the most complete of the kind, so far as I know, ever
bed of coal of considerable thickness. ‘ All the coals afford a f

GEOLOGICAL SURVEY OF CANADA.

and their ashes are light-gray and powdery, with the exception of the coarse coals, which are heavy and shaly. The worst defect of the coal is its containing rather a large quantity of bulky ashes, which it to be less esteemed for domestic use than, on other grounds, it is. It is very free from sulphur, burns long, and with a great proof of heat, and remains alight, when the fire is low, much longer than other coals."

From the analyses, it will be seen, are of coals from the older workings of the old mines and Dalhousie pits. Of the coal obtained from the new pits, I have made the following analyses:—

	HARTLEY.	
	By fast coking.	By slow coking.
Hygroscopic water.....	1.73	1.80
Volatile combustible matter.....	28.18	25.12
Fixed carbon.....	62.94	65.70
Ash (light-gray).....	7.15	7.38
	100.00	100.00
Coke	70.09	73.08
Theoretical evaporative power.....	8.62 lbs.	9.03 lbs.
Sulphur (in average of coal).....		0.32 per cent.

The specimens analyzed were hand-samples from the bank at the Foord and believed to fairly represent the whole mass, which supposition is confirmed by the agreement of my assays with the following analysis by How, of King's College, Windsor, Nova Scotia, of a sample of one sent him by Mr. Hudson, Chief Manager of the General Mining Division.

Coal from Foord pits, Main seam. An average of the large sample analyzed:—

	How.
Moisture	1.48
Volatile combustible matter.....	24.28
Fixed carbon.....	68.50
Ash....	7.74
	100.00
Coke.....	74.24
Sulphur.....	0.55
Theoretical evaporative power.....	9.13 lbs.
Specific gravity, average of three specimens.....	1.294

It follows that this is, for various reasons, a valuable coal. The volatile combustible matter is such in amount and character as to promise well in

gas-making. The coke is firm and abundant, and the high theoretical evaporative power, shewing the number of pounds of water which one pound of coal ought to evaporate from a temperature of 212°F. , (rather above the practical average of 37 Welsh coals), places the coal very high as a steam-producer. The amount of sulphur is decidedly low, obviously an important fact as regards domestic use, gas-making, and preservation of grate bars. The coal lights up readily in a parlour stove, cakes moderately, and gives a hot lasting fire; the ash is nearly five per cent. less than in coal from the same seam examined by Prof. Johnson, in 1842-43, and one or two per cent. less than coal from the *best parts* of the seam, tested by Dr. Dawson, in 1854. This is an important feature, as the large quantity of light bulky ash was then considered the worst defect of the coal. The ash consists chiefly of sandy matters; there is so little lime that there will be but little tendency to form clinkers. The specific gravity is high enough to show good storage character. One cubic foot broken for use should weigh about 52½ lbs., and one ton of 2,240 pounds should occupy, in the same state, about 42½ cubic feet space in storage.

"From its hardness, and the appearance of the contents of the barrel after about 100 miles of railway carriage, I conclude that the coal would bear handling and land-carriage without making much *small*, or dust."*

These remarks and analyses comprehend all that can be theoretically said of the value of the Foord-pit coal. I may, however, state that the coke from this coal is of exceptionally good character, and though all the coals from this seam furnish good coke, that from the Foord-pit coal seems to take the first rank, from its coherent and yet very porous texture. It is very light, of a silvery-gray colour, and a metallic lustre.

COALS FROM THE DEEP, OR CAGE-PIT SEAM, ALBION MINES.

In general appearance, the coal of the Deep seam much resembles that of the Main. A section of the different beds of this seam was examined by Dr. Dawson, in 1854, of which he publishes the following description, with assays of the different beds.†

SECTION OF DEEP SEAM, BY DR. J. W. DAWSON.

1. Gray argillaceous shale.(roof).
2. Tender laminated coal; much mineral charcoal.
3. Laminated compact coal; less mineral charcoal.
4. Laminated compact coal; less mineral charcoal.
5. Carbonaceous ironstone, crusts of *Cyprids*.

Dawson's section of the Deep seam.

*Extract from letter of Prof. H. How, of King's College, (late chemist to the British Admiralty Coal Enquiry), to James Hudson, Esq., G.M.A.

†Acadian Geology, p. 335-336.

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6. Laminated compact coal; much mineral charcoal.
7. Laminated coarse coal.
8. Laminated compact coal.
9. Laminated coarse coal.
10. Laminated compact tender coal.
11. Laminated compact coal.
12. Laminated compact hard coal.
14. Laminated compact hard coal; thick layer of mineral charcoal.
15. Laminated compact coal.
16. Laminated compact coal; much mineral charcoal.
17. Laminated compact coal; much mineral charcoal.
18. Shaly coal; impressions of plants.

the results of assays of the above samples of coals taken, at distances of a foot, in the Deep seam are given in the following table:—

Dawson.				
	Volatile by rapid coking	Volatile by slow coking.	Carbon fixed.	Ashes.
2. } Good coal.....	24.8	21.0	67.6	11.4
3. } Good coal.....	25.2	23.2	67.3	7.5
4. } Ironstone and coal.....	28.4	23.9	70.8	5.3
5. } Coarse coal.....	26.8	27.5	18.5	54.0
6. } Coarse coal.....	23.2	20.5	59.1	20.4
7. } Good coal.....	23.6	20.4	48.0	31.6
8. } Coarse coal.....	26.2	22.4	70.3	7.3
9. } Coarse coal.....	25.2	21.1	49.3	28.6
10. } Good coal.....	24.8	20.4	68.9	10.7
11. } Coarse coal.....	24.8	22.3	64.3	13.4
12. } Coarse coal.....	23.4	20.5	51.2	28.3
13. } Coarse coal.....	23.0	20.1	55.3	24.6
14. } Good coal.....	27.4	23.9	68.1	8.0
15. } Good coal.....	29.0	22.9	71.5	5.6
16. } Good coal.....	26.8	21.9	69.6	8.5
17. } Good coal.....	24.6	19.9	63.6	16.3
18. Shale and coal.....	17.6	21.1	23.0	55.9

The following analysis of a small sample of the coal now being worked on the western face, has been made by Mr. Broome:—

	Broome's Coking.	
	Rapid.	Slow.
Volatile matter.....	28.1	25.5
Fixed carbon.....	71.9	74.5
	100.0	100.0
Proximate water.....		1.296
Volatile combustible matters.....		25.443
Fixed carbon.....		61.650
Moisture.....		.861
		10.250
		100.000
Specific gravity.....		1.33

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The ash from this sample contained 75 per cent. of matter hydrochloric acid, which was chiefly aluminous silicate. Iron estimated in the soluble portion, which, by the volumetric method, metallic iron equal to 2.762 per cent. of the ash. Supposing to exist in this coal as pyrites, this amount would correspond to cent. of sulphur in the coal. As experiment gave a larger proportion evident that some of the sulphur present exists as a sulphate, lime. The ash was gray, with a faint tinge of pink. This color is usual with the coal of this seam. Coke, by rapid carbonization by slow coking, a pulverulent mass was obtained.

To this analysis may be added the results of Prof. How, from examination of a large sample; probably a better average of the whole than the specimen examined by Mr. Broome:—

“ Coal from Deep, or Cage-Pit Seam.—An average of sample sent, (one barrel), gave:—

Moisture	1
Volatile combustible matter	2
Fixed carbon	6
Ash	—
	10
Coke	7
Sulphur	
Specific gravity (average of three specimens)	1
Theoretical evaporative power	1

“ This is an excellent coal, especially for domestic and steam use. As compared with that of the Foord pit, it gives a larger quantity and its theoretical evaporative power is decidedly higher, so that it proves a valuable steam coal. It burns well in a stove, affording enduring heat; its ash not being much above that of the Foord it will also be found superior for domestic uses to the coal found at your mines. The sulphur is not high, as compared with the Foord, though it is rather above the average of that in Welsh steam coals.

“ The ash is chiefly sand; there is very little lime, so there is much clinker formed. From the high specific gravity, one cubic foot of the coal should weigh about 53 lbs., when broken, and a ton of it should be stored in about 42 cubic feet.

“ The coal is harder and less easily broken than that from the Foord

* Extract from a letter from Prof. How to James Hudson, Esq., G.M.A.

COALS OF THIRD AND PURVIS SEAMS, ACADIA MINES.

Third and
Purvis seams.

These seams are now abandoned, and no analyses have been made of the coal from them, as no samples lately taken from the seam could be procured.

COAL OF THE MCGREGOR SEAM, ACADIA MINES.

The following extract is from the Report of Mr. Hoyt to the Acadia Coal Company, 1866 :—

McGregor seam.

"It has been found that the thickness of this coal (the McGregor seam) increases as we progress westwardly, but diminishes as we work to the east.* The same remark will also apply to the quality of the coal. At present, only the upper divisions of the seam are worked. The bottom coal, which is of a coarse nature, is unsaleable, but would be very suitable for iron-smelting†; and in case of the developement of the iron deposits on the East River of Pictou, a good market would be created for it. The slaty band, between the top benches, is a source of much inconvenience and expense in mining; and with all the care exercised in picking, this foreign matter will, to some extent, get mixed with the good coal, which is thereby injured in character for gas purposes.

"The quantity of ash produced by the two top benches presents a marked contrast in the character of the coals, as will be seen by the following analyses, which have been obtained from the former proprietor, Mr. J. D. B. Frazer : "‡

Analyses.

	First bench.	Second bench.
Volatile matter.....	22.50	23.30
Fixed carbon.....	65.70	70.00
Gray ash.....	11.80	6.70
	100.00	100.00
Coke	77.50	76.70
Specific gravity.....	1.334	1.301
From these analyses the theoretical evaporative power would be.....	9.03	9.62

This coal cokes well when the better portions of the seam are selected. A very large amount of iron pyrites exists in the slaty portions of the seam, which, if not most carefully removed, makes the coal worthless as a gas coal. Careful attention in hand-picking, will probably obviate this objection to the coal.

* See p. 96 of my Geological Report.

† I have not analysed this coal from the bottom of the McGregor seam, but it appears to contain too much sulphur and ash to be very suitable for iron smelting.

‡ Name of analyst unknown to me.

The theoretical evaporative power resulting from the second analysis above given is large ; it should render the coal a good steam coal, if the pyrites were removed.

COAL AND OIL-COAL FROM THE STELLAR SEAM.

On page 70 of the Geological Report, it is stated that the Stellar coal seam of the Acadia mines has the following section :—

	<i>Ft. In.</i>	<i>Section.</i>
Good coal.....	1 4	
Stellar oil-coal.....	1 10	
Bituminous shale.....	1 10	
	<hr/>	
	5 0	

These three divisions of the seam are quite separate and distinct in character. The substances from each were examined some time since by Prof. How, who first described the peculiar substance forming the middle bench, to which, from a likeness in some of its qualities to the so called oil-coals, torbanite and albertite, he has given the name of stellarite, from its throwing off sparks or stars of fire when lighted. From the three benches Prof. How obtained the following results :—*

	<i>Coal.</i>	<i>How. Stellarite.</i>	<i>Shale.</i>	<i>Analyses.</i>
Volatile matters.....	33.58	66.56	30.65	
Fixed carbon.....	62.09	25.23	10.88	
Ash	4.33	8.21	58.47	
	<hr/>	<hr/>	<hr/>	
	100.00	100.00	100.00	
Moisture.....		.23		
Specific gravity.....		1.103		

Coal. The coal appears to be merely an ordinary fat caking-coal, with an unusually small percentage of ash for this region, but the bench being thin, the value of the seam depends principally on the two lower divisions, stellarite, and oil-shale.

Stellarite. This peculiar substance was first known and worked at these mines by the former owner, the late Mr. J. D. B. Frazer, of Pictou. It appears to be an earthy bitumen, or, to quote Dr. Dawson, "a fossil swamp-muck or mud," † which he has elsewhere‡ shown, is the character of the earthy bitumens and highly bituminous shales of the coal formation generally.

* How, *Mineralogy of Nova Scotia*, p. 24.

† *Acadian Geology*, p. 339.

‡ See Dawson, "On the conditions of accumulation of coal." *Journal Geol. Soc.* xxii. p. 95 et seq.

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ale or oil-shale. This is a rather heavy brownish-
e following analysis and remarks thereon, include both
e stellarite.

is taken from Mr. Hoyt's Report to the Acadia Coal

3. Analyses under the heading of No. 1 refer to stel-
e oil-shale :—

WALLACE.*		
	No. 1.	No. 2.
rs.....	68.38	38.69
.....	22.35	8.26
.....	8.90	52.20
.....	.05	.25
.....	.32	.60
	<u>100.00</u>	<u>100.00</u>
y.....	1.079	1.568
ic foot.....	67½ lbs.	97 lbs.
ton.....	126 gallons.	63 gallons.
.....	.844	.850
.....	31.25	60.46
ie of stellarite, 28.48 per cent.....	....	....
	<u>100.00</u>	<u>100.00</u>
PENNY.†		
	No. 1.	No. 2.
r.....	67.26	34.16
.....	24.03	12.30
.....	8.40	52.00
.....	.11	.74
.....	.20	.80
	<u>100.00</u>	<u>100.00</u>
r.....	1.069	1.612
ic foot.....	66½ lbs.	100 lbs.
ton.....	123 gals.	60½ gals.
.....	.844	.850

QUANTITY OF OIL BY VARIOUS TRIALS.

(per ton)

. De W. Spurr, St. John, New Brunswick, (No. 2)	
de oil.....	74 gals.
Howarth, Boston, Mass., by steam process, crude oil.	65 "
. Macdonald, Portland, Maine, (No. 2), crude oil..	50 "

, the following results from these and other oil-coals are
ble is taken from How's Mineralogy of Nova Scotia :

Glasgow, Scotland.
ersonian University, Glasgow, Scotland.

	Crude oil per ton.
Union oil-coal of West Virginia affords.....	32 gals.
Elk River " " " " "	54 "
Kanawha " " " " "	88 "
Leshmahagow cannel, Scotland "	40 "
Albertite, New Brunswick,	93 to 100 "
Torbanite, Scotland,	116 to 125 "
Stellarite,	53 "
" No. 2 (shale)	50, 60½, 63, 65, 74 "
" No. 1,	123 to 126 "
" picked samples gave in Boston.....	199 "

In practical working at the Frazer mine the result was about 60 gallons of crude, and from 80 to 85 gallons of fine clarified oil to the ton.

It will be noted that the three oil-coals, or bitumens, known as torbanite, albertite, and stellarite, in the list just given, appear to afford the best results in oil-manufacture. It will, therefore, be of interest to compare full analyses of these three, forming a class by themselves, and again to compare this class with other mineral combustibles from which they differ to a greater or less extent. This subject has been thoroughly investigated by Prof. How, and the following tabulation of analyses, and conclusions drawn therefrom, are taken from his late work. Although most appropriately introduced here, many of the facts will be found useful for comparison with coals of other seams, and the remarks on the theoretical value of fuels is also of general interest.

"Having, on account of my former connection with the British Admiralty Coal Enquiry, been one of those engaged to furnish chemical evidence in the famous first trial in Edinburgh of the question whether the mineral known as "Boghead coal," found at Torbane Hill, Linlithgowshire, should properly be called a coal, I was naturally much interested on the discovery of the stellar oil-coal, and got ultimate analyses made of it and of the "Albert coal," also the subject of a trial on the ground that it had been improperly called coal. These analyses were very kindly made for me through Prof. Anderson of Glasgow, who generously met my deficiency in the necessary apparatus, which I had not brought out with me. The results were most interesting, especially when compared with those obtained from bituminous and cannel coals. As to the former, I selected from those I had made in the Admiralty Enquiry, analyses of English, Scotch, and Welsh bituminous coals, and as to the latter, analyses of English and Scotch cannels made by other chemists. The following table shews the differences which obtain between these minerals in proximate and ultimate analysis, and in specific gravity, and the ratio existing between the two most important constituent elements :—

Dr. How's
remarks on oil-
coals.

MINERAL.	Locality.	Specific gravity.	Proximate analysis.				Ultimate analysis.				Ratio of carbon to hydrogen.	Authority.
			Volatile matters.	Fixed Carbon.	Ash.	Carbon.	Hydrog.	Nitrogen.	Sulphur.	Oxygen.		
Welsh bituminous coals.	Duffryn	1.328	15.70	81.04	3.26	88.28	4.66	1.45	77.0	60	100: 4.83	H. How
	Newydd	1.310	15.20	71.58	3.24	84.73	5.76	1.55	31.3	53	100: 6.79	"
	Ebbw Vale	1.276	22.50	76.00	1.50	98.79	5.15	2.16	1.03	0.38	100: 5.73	"
Scotch bituminous coals.	Grangemouth	1.230	43.40	58.08	3.52	79.86	5.22	1.9			100: 6.61	"
	Fordel	1.025	47.97	48.03	4.00	79.58	5.50	1.1			100: 6.93	"
English bituminous coals.	Broomhill	1.025	40.80	56.13	3.07	81.70	6.17	1.9			100: 7.55	"
	Lydney	1.293	43.20	47.80	10.00	78.52	5.09	2.0			100: 7.73	"
Eng. cannel. Scotch canals.	Wigan	1.376	39.44	57.06	3.70	90.07	5.53	2.1			100: 6.90	Vaux
	Leamhagow	1.261	55.70	37.26	5.03	78.44	7.32	1.9			100: 10.43	Miller
	Capeldrac				25.40	58.70	6.80	1.9			100: 11.96	A. Fyfe
Torbanite.	Torbanhill, Scotland	1.170	71.17	7.85	21.18	66.00	5.58	0.5			100: 13.00	H. How
	Hillsboro, New Brunswick	1.091	54.26	45.44	0.17	87.26	9.22	1.7			100: 11.03	Slesor & How
Stellarite.	N. Glasgow, Nova Scotia	1.103	66.53	25.23	8.31	80.93	10.15	0.6			100: 12.58	"

* Nitrogen and oxygen 11.76. † Sulphur (if any) and oxygen, 1.21. ‡ N, S, and oxygen .08.

"In the paper in question I pointed out that the true comparative value of combustible minerals, while partly indicated by the relative amounts of volatile matter and fixed carbon, is only truly shewn when account is taken of the oxygen; which is sometimes large in quantity, as is seen above, and is reckoned as volatile matter, to the credit of the mineral, while its real effect is reduction of value. I showed that when the hydrogen equal to the oxygen present is deducted, taking only those cases where there is an apparent equality in the ratio of carbon to hydrogen, the last three minerals in the table above, stand apart from the rest, thus:—

Ratio of carbon to hydrogen after deducting hydrogen equal to oxygen present.

Cannel coal from Wigan	100 to 5.65
" " " Leamhagow	100 to 8.71*
Capeldrac	100 to 10.05
Torbanite from Scotland	100 to 12.43
Albertite " New Brunswick	100 to 10.85
Stellarite " Nova Scotia	100 to 12.43

* Allowing two per cent. for nitrogen.

and that theoretically they should be excellent 'oil-coals,' as is abundantly shewn by experience."

Description of stellar seam.

The size of the stellar-coal bench in the oil-coal seam varies from four or five inches in thickness to some two feet, and its content of oil varies also. As a rule, this seam appears to improve going eastward, as stated by Mr. Hoyt. The general appearance of the stellar coal is peculiar; it is irregularly bedded, the different layers seemingly interlaced, giving it a sort of an entangled appearance, or a structure like

* How, Mineralogy of Nova Scotia, p. 25-26.

felt. Sometimes the layers are much curved, and have smooth surfaces like slickensides, which appear to have been produced by lateral movements, corresponding very nearly with the plane of the bed, rather than by vertical motion, the better portions generally possessing this peculiarity, whence the statement in many notices of this substance that the *curly* oil-coal is the best. The surfaces of these curved faces have a bright, resinous lustre, and a brownish-black colour, while a block sawn across shews a uniform *dead*-brown surface. It breaks with a splintery fracture, very irregularly, but approximately with the surfaces of deposition; the streak has a brown colour and a dull resinous lustre.

A large splinter of this mineral may be easily lighted with a match, and burns with a very bright, carbonaceous flame, throwing off sparks like stars, (whence the name), and leaving but a small amount of coke, from which, on burning off the fixed carbon, a grayish-white ash is obtained. Further remarks on the use of this mineral in gas-making, will be found in Section II of this Report.

COAL OF THE ACADIA SEAM, ACADIA COLLIERY.

ACADIA STEAM COAL. The principal value of this coal, is (as its name indicates) as a steam-coal, though a portion of the seam at this colliery may be suitable for gas-making. As the character of the coal as a steam-producer will receive the fullest attention in the second section of this Report, it has been deemed unnecessary to make any analyses of it as yet, though when time permits I hope to obtain a full series of analyses of the coals from different benches of the seam, by examination of a series of specimens presented by Mr. Hoyt. In the meantime I offer my practical locomotive and steamer-trials, with some other tests of considerable interest, in Section II, which I consider will give abundant evidence of the excellence of the Acadia steam-coal.

Only one analysis of this coal has been made in the laboratory of this Survey, that of samples of the coal taken from the third bench, or the four feet immediately underlying the fireclay parting. (See page 97 of my Geological Report.) These specimens were selected for analysis, because I believe this bench to be better fitted for gas purposes than the rest of the seam, being apparently the softest coal afforded by the Acadia seam at this colliery.

The analysis has lately been made by Mr. Broome, with the following results:—

	BROOME Coking.		Analysis.
	Rapid.	Slow.	
Coke.. .. .	65.12	68.70	
Volatile matters.....	34.88	31.30	
	100.00	100.00	

Hygroscopic moisture.....	2.100
Volatile combustible matter.....	32.274
Fixed carbon.....	57.570
Sulphur.....	.506
Ash, (pinkish white).....	7.550
	<hr/>
	100.000
Specific gravity.....	1.32

The coke by rapid carbonization was firm, but by slow heating a pulverulent mass was obtained.

This analysis shows that a portion of the seam at the Acadia colliery will coke well, and that it contains sufficient volatile matter to make a gas-coal. The greater part of the seam is a much harder coal than the specimen examined, and, when all the benches are mixed, does not coke satisfactorily in open heaps, and is therefore sold only as a *free-burning* or steam-coal. Were it desirable, however, I think the third bench could be easily separated in the working of the seam.

The coal of this seam is rather more compact in appearance than that from the Main at the Albion mines, and shows but little mineral charcoal on the deposition-planes. The cleat planes and cross fractures of the coal are usually very brilliant, and do not show the laminæ or deposition-planes very clearly.

COAL OF THE ACADIA SEAM, DRUMMOND COLLIERY.

Drummond
coal.

Description of
seam worked.

From a careful examination of the different benches of coal in the working, and subsequent examinations of a series of large samples of the coals presented by Mr. Dunn, manager of the Intercolonial Coal Company, I am enabled to present the following description of this fine seam of coal, as worked at the Drummond Colliery. With my description of the benches, analyses will be given, forming what I believe to be the most careful and complete series of assays ever made of different benches of any seam of considerable thickness. These analyses have lately been made in the Survey laboratory by Mr. Gordon Broome, F.G.S., chemical assistant to Dr. T. Sterry Hunt, chemist and mineralogist to this Survey.

Description and analyses of the benches of the Acadia seam at the Drummond Colliery, Pictou County, Nova Scotia.

Roof-shale.

Roof-shale; black, highly carbonaceous shale, giving a dark brown streak, and containing *Spirorbis* and *Cythere* shells, with *Antholites*, *Lepidodendron*, *Lepidostrobus*, not specifically determined, and *Cordaïtes borsifolia*.

Top coal.

1. *Top coal*; not taken out in the workings. This is left in as a support for the roof. Coal good, principal partings show mineral charcoal, and have

APPENDIX TO REPORTS ON THE PICTOU COAL FIELD

rather a dull lustre. On cleat surfaces the general lustre is bright. The laminae of deposition show plainly in lines of brilliant and dark. The joints are rather irregular, generally inclined about $<80^{\circ}$ to the deposition-planes, but the surface next to the lower parting, (parting,) shows two regular sets of joints at right angles, giving a cubical appearance.

Thickness of *top-coal* bench, 2 feet, 6 inches.

ANALYSIS NO. 1; TOP COAL.

Volatile at 100° C., (moisture).....	.....
Volatile at 220° C.,.....	.....
Total volatile, 1. By slow coking.....	.....
" " 2. By fast coking.....	.....
Coke, 1. By slow coking.....	.....
" 2. By fast coking.....	.....
Volatile matter.....	.....
Fixed carbon.....	.....
Ash, (gray).....	.....
Sulphur.....	.....

Specific gravity.....

2. *Fall Coal*; immediately above the fireclay parting, or being the first bench taken down. Coal good; surfaces of deep dead-black patches of mineral charcoal, with bright points, and bright bituminous matter. Cleat surfaces brilliant, the joints in two systems, giving this bench in some parts of the workings, as it is technically called, *dacey*, structure. The surfaces of the joints show oblong or oval scars, as of *shrinkage*, while of the set the surfaces are quite regular and brilliant.

Thickness of *fall-coal* bench, 3 feet, 3 inches.

ANALYSIS NO. 2; FALL COAL.

Volatile at 100° C., (moisture).....	.....
Volatile at 220° C.....	.....
Total volatile, 1. slow coking.....	.....
" " 2. fast coking.....	.....
Coke, 1. slow coking .....	.....
" 2. fast coking.....	.....
Volatile matter.....	.....
Fixed carbon.....	.....
Ash (gray).....	.....
Sulphur.....	.....

Specific gravity.....

GEOLOGICAL SURVEY OF C

First bench; (below the holing.) Coal her of cleat and fracture, are brilliant, and little mineral charcoal. The joints are , cutting the coal up into oblique prism and bright coal.
thickness of *first bench*, 4 feet.

ANALYSIS NO. 3; COAL OF FIRST

Volatile at 100° C., (moisture).....
Volatile at 220° C.....
Total volatile, slow coking.....
" " fast coking.....
Coke, slow coking.....
" fast coking.....
Total volatile matter.....
Fixed carbon.....
Ash, (gray)
Sulphur.....

Specific gravity.....

Second bench; (so marked in specimens ated and cubical ; in some parts of the se distinct. On the surfaces of the depos al charcoal, but all the other surfaces are

ANALYSIS NO. 4; COAL OF SECOND

Volatile at 100° C., (moisture).....
Volatile at 220° C.....
Total volatile, slow coking.....
" " fast coking.....
Coke, slow coking.....
" fast coking.....
Total volatile matters.....
Fixed carbon.....
Ash, (gray).....
Sulphur.....

Specific gravity.....

Third bench; the lower two feet of good forming the bottom of the seam. Coal goo so bright as the first and second benches sition-planes are a dull black, showing muc

my Geological Report, p. 100, I have associated th is now called the third bench.

APPENDIX TO REPORTS ON THE PICTOU COAL FIELD.

planes show laminæ of deposition plainly, and in the joints, in m are seen scales of calc-spar.

ANALYSIS NO. 5; COAL OF THIRD BENCH.

Volatile at 100°C., (moisture).....	1
Volatile at 220°C.....	13
Total volatile, slow coking.....	29
" " fast coking.....	31
Coke, slow coking.....	70
" fast coking.....	68
Total volatile matters.....	30.7
Fixed carbon ...	59.6
Ash (gray).....	8.7
Sulphur.....	.5
	<hr/>
	100.0
Specific gravity.....	1.3

6. *Coarse-coal bench*, bottom of seam ; thickness about 2 feet, Coal coarse and shaly ; deposition-planes show uniform dead-black Coal breaks with irregular fractures in all directions, giving surfaces of a dull lustre and brownish black colour. Not worke

ANALYSIS NO. 6; COAL OF THE COARSE-COAL BENCH.

Volatile at 100°C., (moisture).....	1.
Volatile at 220°C.,.....	und
Total volatile, slow coking.....	29
" " fast coking.....	31
Coke, slow coking.....	72.
" fast coking.....	69.
Total volatile matters.....	32.
Fixed carbon.....	37.
Ash, (red).....	31.
Sulphur.....	und
	<hr/>
	100.
Specific gravity.....	17

The cokes of Nos. 1, 2, 3, 4, 5, obtained by the carbonizat coal in the small way, (in a crucible), were all strong and light by slow or rapid heating, though of course more compact with a bonization. When heated rapidly the coke swells greatly, an silvery-gray colour and metallic lustre. All these benches properly managed, furnish an excellent coke in the large way. single exception of the Foord-pit coal, no coal from this region have examined has given as good a coke in the crucible. The No. 6, or coarse coal, is soft and brittle.

The amount of ash in the different samples is lower than th

of Pictou coals, and the sulphur-content is, in samples I., II., IV., V., decidedly low. The coal of the second bench appears to give the greatest amount of sulphur, being somewhat over the average of the best Welsh coals, but in the coal of the whole seam, when mixed together, the amount of sulphur will be found to be exceptionally small.

Drummond coal
for gas-making.

From the amount of volatile matter, as shown by these analyses, these coals, (*i. e.* the good coals of the seam,) should all belong to the class of gas-coals; in the first bench, No. 3, the content of volatile matter is very large, and about equal to the average of Newcastle coals, when rapidly carbonized. A reference to the report of Mr. Thompson, of the Pictou gas-works, on this coal, (which is published in Section II of this Report,) will show that in this case the conclusions of theory agree with practical results.

With regard to their use as steam-producers, theory gives the following indices of their evaporative powers:—

Theoretical eva-
porative powers.

I.	Fixed carbon	60.35 per cent	= 8.29 lbs. water to 1 of coal.
II.	"	60.32 "	= 8.29 lbs. " "
III.	"	55.39 "	= 7.61 lbs. " "
IV.	"	60.31 "	= 8.29 lbs. " "
V.	"	59.89 "	= 8.27 lbs. " "

It will be seen that a remarkable uniformity exists between the coals of I., II., IV., V., and that their theoretical evaporative powers are rather high for coals of this class, while III. falls rather below the average in fixed carbon. In this connection, however, I would draw attention to the fact that coals of this class are now burnt so as to give an evaporative power considerably above the theoretical index calculated from the fixed carbon of the coal alone. This subject has already been incidentally referred to in the introduction to this Section,* and will also receive special attention in Section II.

COAL OF THE ACADIA SEAM FROM THE NOVA SCOTIA COLLIERY.

Nova Scotia
Co.'s Coal.

A section of this seam, giving details of the character of the coals of the different benches, has been included in the Geological Report, † and the following analyses of three specimens of the coal, by Prof. B. Silliman, of Yale College, New Haven, Connecticut, have been sent me by Mr. F. W. Northrop, Secretary of the Nova Scotia Coal Company:—

Silliman's analysis.	SILLIMAN.		
	(1) Top.	(2) Middle.	(3) Bottom
Volatile matters.....	32.68	32.39	33.45
Fixed carbon,.....	62.08	62.40	61.41
Ash.....	5.24	5.21	5.14
	100.00	100.00	100.00

* See note on North Country coals, page 3.

† Pages 103-104 of the Geological Report.

From these analyses the theoretical evaporative power of the different samples would be :—

Of No. 1, 8.53 lbs.;—of No. 2, 8.57 lbs.,—of No. 3, 8.44 lbs.

In the letter accompanying these analyses, Prof. Silliman makes the following statements :—

“The coke is firm and strong, while the ashes are light coloured, and so nearly free from oxide of iron as to warrant the belief that they will not give much clinker when the coal is used in a furnace. The amount of sulphur in the coal was not determined, as the quantity is too slight to render an experiment in the small way of any practical value.”

It would appear from these analyses that there is a change in the character of the coal of the Acadia Seam between the Acadia and Nova Scotia collieries similar to that between the Acadia and Drummond collieries, and if the specimens analyzed by Prof. Silliman were fair representative samples of the whole seam, this should be, theoretically, a good gas-coal.

Change in the Acadia seam.

COAL OF THE MONTREAL AND PICTOU SEAM.

MONTREAL AND PICTOU COLLIERY.

The works of this company having been abandoned before my visit, and the pit being full of water, during my stay in the region I was unable to procure samples of the seam or seams met with in the workings. The following note by Prof. How is, I believe, the only reliable information at present attainable concerning this coal :—

Montreal and Pictou Co's. coal.

“*Coal of the Montreal and Pictou Mines.* I examined several samples of the coals raised on the first opening of the seams ; the following is an abstract of my Report made to the company as respects the qualities of the coals.

How's analyses

“Sample No. 1, from the first bench, gave :—

First bench.

Moisture	4.40
Volatile combustible matter.....	24.95
Fixed carbon.....	61.07
Ash.....	9.58
	<hr/>
	100.00
Coke	70.65
Theoretical evaporative power.....	8.39

“This coal has considerable evaporative and heating power, and would give a moderate amount of gas of good illuminating quality. The appearance of the coal is much in its favour ; some that I saw taken from the seam was very clean and bright.

“Sample No. 2, from the second bench, gave :—

Moisture	5.47
Volatile combustible matter.....	19.93
Fixed carbon.....	68.55
Ash	6.05
	<hr/>
	100.00
Coke	74.60
Theoretical evaporative power.....	9.41
Specific gravity	1.36

"This was an extremely bright and clean coal. Its very high evaporative power makes it occupy a good position among British and American coals for steam purposes."^{*}

COAL OF THE MONTREAL AND PICTOU OIL-COAL SEAM.

On page 106 of the Geological Report, mention is made of a small seam known on the Montreal and Pictou area, which I am inclined to identify with the Stellar seam of the Acadia mines. I have been unable to procure a good sample of the oil-coal from this seam, but a small specimen taken from the out-crop on the quarry road, much weathered and by no means fairly representing the seam, has been analysed by Mr. Broome with the following result:—

	Broome.
Volatile at 100° C., (moisture).....	2.40
Volatile at 200° to 250° C.....	34.20
Total volatile matter.....	47.35
Fixed carbon.....	34.05
Ash, (very red and ferruginous).....	18.60
	<hr/>
	100.00

This substance is, in external character, very much like the stellarite. It presents the same dead-brown fracture, and shows glistening points of bituminous matter, which, on being ignited, melt and drop from the fragments. The facility of its ignition and continuity of combustion of a small piece, when removed from the flame in which it has been lighted, is only equalled among the oil-coals of the region, by the stellarite, and these facts, together with the results of Mr. Broome's analysis, tend to confirm my identification of the seams.

COAL OF THE CULTON SEAM; CULTON ADIT.

I have been unable to obtain a specimen of the coal of this working. Its character has been described to me by several who have burnt it, as that of an exceptionally good, and very highly bituminous coal.

^{*} How, *Mineralogy Nova Scotia*, p. 27-8.

COALS OF THE EAST SIDE OF THE EAST RIVER.

COALS FROM MCBEAN'S EIGHT-FEET SEAM, MCBEAN'S SLOPE.

First Bench. Upper twelve inches of the seam.

The coal is a bituminous coal, with dead-black planes of deposition, showing little mineral charcoal. It is inclined to be a little shaly, but the cleat and cross-fracture surfaces are brilliant. The following analysis is the result of an examination of two specimens from quite near the out-crop :—

	HARTLEY.		Analyses.
	I.	II.	
Hygroscopic water.....	1.57	2.67	First bench.
Volatile combustible matter.....	29.29	28.65	
Fixed carbon.....	52.36	49.66	
Ash (white).....	16.76	19.42	
	100.00	100.00	
Coke	69.14	65.08	

These samples analysed were taken by myself from the seam, and were apparently an average of the bench. The coal burns well, forming a very hot flaming fire, and the ash, though bulky, is perfectly white, free from iron, and would fall at once through grate bars. No sulphur was discovered by ordinary tests. The coke does not hold together well.

Second bench, (about twelve inches below first bench.)

In appearance this coal is similar to the last, except that there appears to be no mineral charcoal visible on the planes of deposition, and the lustre of the cleat planes is very brilliant. The specimens analysed are from the slope about 40 feet from the crop, and show scales of calc-spar in the joints. Analysis I is from the top of the bench. Six inches below is a smooth parting, and analysis II, is from coal just below the parting.

	HARTLEY.		Analyses.
	I. Top of Bench.	II. Bottom.	
Hygroscopic water.....	2.67	1.94	Second bench.
Volatile combustible matter.....	27.20	23.95	
Fixed carbon.....	54.86	57.17	
Ash (white).....	15.27	16.94	
	100.00	100.00	
Coke.....	70.13	74.11	

Bottom bench (lower six feet of seam).

This coal shows but little tendency to break with the lamination, and no mineral charcoal is seen, even the deposition-planes being brilliant. Fracture conchoidal. It burns freely, giving a very hot fire ; the ash is very light, sandy and not inclined to clinker ; it would fall at once through the grate bars of a furnace. No sulphur was found by ordinary tests.

Bottom bench.

The samples analysed were taken about 50 feet from the crop. The coke, if the coal is properly carbonized, is very fair. The following analyses of averages have been made :—

	HARTLEY.	
	I.	II.
Analyses.		
Hygroscopic water.....	2.22	3.00
Volatile combustible matter.....	30.23	29.61
Fixed carbon.....	59.70	59.51
Ash (white).....	7.85	7.88
	<hr/>	<hr/>
	100.00	100.00
Coke.....	67.55	67.39

This coal should make an good gas-coal, as the percentage of volatile matters is quite large in comparison with many of the coals of the district. I am not aware that any practical trial has ever been made of it as a gas-producer. From its rapidity of combustion and freedom from sulphur, it would also appear to be well fitted for ordinary steam purposes.

COAL OF THE GEORGE MACKAY SEAM, MARSH COLLIERY.

George Mackay seam. This coal is coarsely laminated ; the deposition-planes have a very dull lustre, and show a great many patches of mineral charcoal. The cleavage planes are inclined $<83^{\circ}$ to the bedding ; the joints show many scales of calc-spar, which is not adherent to the coal, but crumbles under the finger.

Coal of Marsh Colliery. The following analyses of two specimens from the Marsh pit, 240 feet deep, and striking the coal seam about 1,000 feet from the crop, show this coal to be of very good quality, notwithstanding its rather coarse appearance :—

	HARTLEY.	
	I.	II.
Analyses.		
Hygroscopic water.....	none.	none.
Volatile combustible matter.....	29.72	29.98
Fixed carbon.....	62.28	62.15
Ash, (buff coloured).....	8.00	7.87
	<hr/>	<hr/>
	100.00	100.00
Coke.....	70.28	70.02

The percentage of ash is decidedly low. A trace of sulphur was found, but being, probably, under one-half of one per cent., was not estimated. As the specimens examined do not coke particularly well, it would appear that this coal is best fitted for a steam-coal.

COALS OF LAWSON'S SEAM ; LAWSON'S SLOPE.

LAWSON'S seam. The specimens examined were taken from the slope sunk by Mr. J. P. Lawson, M.E., for the Montreal and New Glasgow Coal Company, on the

left bank of Potters' Brook, near the Merigomish telegraph road. At this working, the seam, as measured by me, was divided into the following benches :—

	FT. In.	
Cannel coal, (varies in thickness,) about.....	0 6	Se
Mineral-charcoal bench.....	0 2	La
Good coal.....	2 7	
Coarse (but good) coal.....	0 5	
	<hr/>	
	3 8	

Cannel-coal bench.—This coal appears to be a true cannel, being of a homogeneous texture, and dead grayish-black colour. The fracture is conchoidal, lustrous, streak brownish-black. In some places this cannel becomes shaly, breaking roughly with the deposition-planes, which are a dull black and in many cases tinged dark red with iron rust from iron pyrites, which occurs in small lenticular masses ; cleat planes vertical to the bedding. One specimen shows a coprolite. A picked sample of this bench gave :—

	HARTLEY.	
Hygroscopic water.....	.47	A
Volatile combustible matter.....	41.18	
Fixed carbon.....	48.19	
Ash, (reddish or purple).....	10.16	
	<hr/>	
	100.00	

This specimen gave a very large quantity of very highly carburetted gas, but the coke is not of the best quality.

Mineral-charcoal bench. Interlaminations of mineral charcoal and bright bituminous coal form the material of this bench. The specimens examined show small veins of calc-spar in the joints of the coal, which are in many cases inclined at an angle of only 45° with the bedding. This bench shows a great deal of iron pyrites, coating the patches of mineral charcoal with a bright film, and giving them the appearance of having been gilded. Not analysed.

Good-coal bench. Colour of coal dull black, very compact and heavy, with occasional patches of mineral charcoal. It shows but little tendency to break with the planes of deposition, and has generally a sub-conchoidal and sometimes a ragged fracture. The specimen examined contains a great deal of sulphur, in the form of iron pyrites, which if present in the mass of the coal, would altogether unfit it for steam or domestic uses. It burns, however, with a very bright and hot fire, though the ash is very bulky, and sometimes chokes the fire if not properly cleaned.

The following analysis of this coal is given in a report by Dr. J. W. Dawson, to the owners of the East River coal area :—

	DAWSON.
Volatile matter, (moisture included).....	25.4
Fixed carbon.....	50.0
Ash.....	24.6
	<hr/> 100.0

The ash from this coal is generally red or reddish-gray.

Coarse-coal bench. The coal of this bench is very coarse in texture, having two sets of cleavage joints, very distinctly marked, which, with the lines of deposition divide it up into small cubical blocks, giving it the appearance known technically as *dicey*. The surfaces of the coal along the joints are generally rendered very dull in colour from the presence of a clay from the underclay of the seam, which softens when exposed to the atmosphere or percolating water, and is forced by the superincumbent pressure up into the open joints of the coal, presenting the phenomena of *creep*, on a very small scale. This coal, were it not for its tendency to crumble (from its open texture), would be an especially good coal, as may be judged from its extreme lightness. The following analysis of a specimen from this bench presents a most remarkable contrast in content of ash (made of the fireclay in its joints) to the overlying bench:—

	HARTLEY.
Hygroscopic water.....	1.82
Volatile combustible matter.....	28.47
Fixed carbon.....	63.93
Ash, (buff-coloured).....	5.78
	<hr/> 100.00

A determination of ash in another sample, gave 6.07 per cent.

COAL FROM THE "OLD FRAZER MINE." *

I have not examined the coal from this seam, but on the authority of J. Dawson, it is stated to be "a good coal of uniform quality." † He distinguishes the seam in his Report, as the *Foster seam*, and gives the following analysis of the coal:—

	DAWSON.
Volatile matter, (including water).....	29.0
Fixed carbon.....	53.4
Ash, (reddish gray).....	17.6
	<hr/> 100.0

Report of Sir William E. Logan, p. 44.

Report of Dr. J. W. Dawson to East River Coal Company.

COAL OF THE RICHARDSON SEAM, (PIT AT THE CROWN POTTERY.)

In appearance this coal is rather coarsely laminated, and its only tendency to break is roughly with the deposition-planes. In colour it is jet-black, the only perfectly black coal examined, and in the specimens analysed, all the surfaces, whether of deposition-planes or fracture, were brilliant, showing no trace of dead-black mineral charcoal, a very unusual thing with coals of this district. It is the most highly bituminous *true* coal of the district (so far as I am aware,) and I should judge from the analysis that it would be an admirable gas coal, for which purpose it should be tested. It gives a very good coke, and the ash is very light, perfectly white, and silicious or sandy, and therefore will not be inclined to clinker. On the whole this seems to be a coal of remarkable purity, if fairly represented by the specimens I have seen. The pit not being open during my visit, samples were taken from a small heap of coal lying beside it, which however, had been for some time exposed to the weather. The following is an analysis of an average of these samples:—

	HARTLEY.	
Hygroscopic matter.....	.76	At
Volatile combustible matter.....	38.84	
Fixed carbon.....	55.81	
Ash, (white).....	5.09	
	100.00	
Coke.....	60.20	

No sulphur was detected by ordinary tests. The content of ash, it will be observed, is lower than in any other coal of the district of which an analysis is given in this Report, with a single exception. Should the Richardson seam be proven over any considerable area, it would seem probable that, although quite small, it might be profitably worked with fair prices of coal, especially if taken out in connection with a valuable bed of fireclay, which underlies it a few feet, and which has already been worked to a small extent for pottery and fire-brick manufacture, by the Crown Brick and Pottery Company of New Glasgow.

UPPER OIL-COAL OR OIL-SHALE SEAM.

The substance included in this seam varies very greatly in external character between the two extreme points where it is known, at Haliburton's pit on the Marsh Brook, and at Andrew Patrick's old slope on McLellan's Brook, a short distance below the Fulling-mill bridge.

OIL-COAL FROM ANDREW PATRICK

Andrew
Patrick's oil-
coal.

The oil-coal from this mine occurs both shaly and friable, appearing to be the most valuable. The texture much resembles the stellarite in appearance and has a lighter brown colour. It weathers a bluish-grey. The following analysis has been made by Mr. Broome of some large samples selected by Sir William E. Logan in 1868 :—

	BROOME.
Volatile below 200° Centigrade, water and some oil.....	.67
Volatile at 200° C., (oil).....	14.73
Total volatile matter.....	33.91
Fixed carbon.....	6.11
Ash (grayish-brown).....	59.88
	<hr/>
	100.00
Coke.....	66.09
Specific gravity	1.747

This oil-coal has been used in the manufacture of burning-oil, I believe, but I am not aware of the quantity of oil produced per ton.

OIL-COAL OR SHALE, FROM THE MARSH BROOK.

Oil-coal from
the Marsh
Brook.

This substance appears to be an argillaceous shale, of a grayish-black colour, giving a brownish streak; the bedding is not well marked, except on surfaces of fracture, where the lamination can be traced by numerous small brilliant points; apparently bituminous, which are included between the laminæ. A thin section of this oil-shale under the microscope presents the appearance of a dark brown or black ground, nearly opaque, with numerous spots of yellow, which are translucent; the black ground being the shale, and the yellow points the included hydrocarbonaceous matter. The following analyses of this substance have been made, the first being of a specimen procured in 1868, by Sir William E. Logan, from the pit on the Marsh Brook known as Haliburton's pit:—

Analysis.

	HARTLEY.
Hygroscopic water.....	1.02
Volatile combustible matter.....	27.44
Fixed carbon.....	9.26
Ash, (grayish-brown, shaly).....	62.38
	<hr/>
	100.00
Specific gravity.....	1.68

Since the above analysis was made, I have procured other specimens from the same pit, one of which was analysed by Mr. Broome, with the result:—

	BROOME,
Volatile at 100° C. (water and some oil).....	.596
Volatile at 200° C.....	11.260

No. 1, Rapid coking.

Total volatile matter.....	40.600
Fixed carbon.....	.400
Ash, (grayish-brown).....	59.000

100.000

No. 2, Slow coking.

Total volatile matter.....	35.540
Fixed carbon.....	5.260
Ash.....	59.200

100.000

The above results show that this shale is composed almost entirely of volatile matter and ash, the amount of fixed carbon being dependent on the rapidity of carbonization. This shale has been tested for oil, but the results I have not heard. Theoretically, it should be a valuable oil-shale.

II.

PRACTICAL TRIALS OF PICTOU COALS.

Value of practical results.

In the first portion of Section I, I have already drawn attention to the great importance of practical trials of coals as steam and gas-producers, and for other purposes of the industrial arts; and I have incidentally mentioned that several series of experiments on coals, with a view of ascertaining their evaporative value, had been carried out, so far as the coals of Great Britain and the United States were concerned, by the British and American governments, respectively. My attention was especially called to this matter during my examination of the Pictou district, while endeavouring to collect materials for a report on the coals of that region: by the almost total ignorance prevailing, of what work the coals could practically perform, or for what work they were best fitted. With one exception no figures could be obtained which would prove any of the coals to be valuable as steam-coals, that exception being the values furnished by a trial incidentally made (for comparison) by the American Government, during the series of trials of United States coals;—of the Albion-mines coal shipped in 1843 or 1844, when the upper twelve feet of the Main seam was the only coal worked. Although fully satisfied, from observing the success with which the coals were burnt, in the region, under stationary, locomotive, and marine boilers, that many of the coals were well fitted for steam-producers, I was, at the same time, aware that a report merely giving my own opinion, would not have the value that would attach to a report of systematic trials, of which the results could be stated in figures. Being aware that no experiments could be undertaken similar to those of the Admiralty and American navy trials, it became necessary to devise some plan by means of which the use of the necessary apparatus could be obtained without great expense. The proper method would have been, of course, the use of the same boiler for all coals, which boiler should be fitted with proper grates, flues, etc., for burning each coal in the most economical manner. As this would have entailed the erection of such an apparatus at the public expense, it appeared out of the question, and the only plan seemed to be to make such trials on locomotives and steamers as could be carried out with a small expenditure, through the liberality of the coal-owners, or other parties interested in knowing the true value of the coals.

Plan adopted for steam-trials.

Having obtained the consent of Sir William E. Logan, then Director of this Survey, I broached the subject to the agents of the several collieries which were in active operation, about the middle of the month of October

last, and, through their kindness, several trials were at once arranged for. Coal trials.
Through Mr. Jesse Hoyt, Manager of the Acadia Coal Company, I was permitted to make a trial of the Acadia steam-coal on the Provincial or Nova Scotia) Railway, by Mr. Lewis Carvell, General Superintendent of the railways of the provinces of Nova Scotia and New Brunswick, and many facilities were granted me by him, and all the other officials of the Railway Department.* At Mr. Carvell's request, another trial was made, shortly after, on the same railway, with wood, for a comparison of the two fuels.

Through Mr. Hoyt, and Mr. Hales, Manager of the Prince Edward Island Steam Navigation Company, a second trial of the Acadia coal was then made, on the steamer "St. Lawrence," of the P. E. I. Navigation Company's line. As before, I was granted every facility by all the officers of the line, and especially by Mr. Hales.

A third trial was that made with wood on the Provincial Railway, as Wood trial.
above referred to. This was undertaken at Mr. Carvell's request, in order to institute a comparison between wood and coal by practical experiment. By reference to that portion of this section headed 'Comparison of Coal and Wood,' it will be seen that the results were greatly in favour of coal.

Coal from the Acadia West colliery had been used on the Windsor branch of this railway, for some months, but, so far as I am aware, no train had been run over the main line from Pictou to Halifax with a coal-burning engine previous to my experimental train—the fuel hitherto used having been wood, furnished the railway by contract. I believe that the final result of my comparative experiments will be the complete abandonment of wood as a fuel on this railway, (so soon as the engines can be fitted for burning coal,) with very considerable saving in expense and time.†

The fourth trial was made on December 3rd., through the kindness of Mr. Dunn, Manager of the Intercolonial Coal Mining Company, on that Company's railway, with a Scotch coal-burning engine, and a loaded coal-train. In this experiment I was materially aided by Mr. William Crawford, C.E., the Company's Chief Engineer, who accompanied me on the engine, and noted the times of passing many points, by means of which a very complete record of the performance of the engine was obtained. A previous trial had been attempted on this railway, but it was stopped by stormy weather (rain and sleet), which prevented a proper adhesion of the driving-wheels to the rails. I am much indebted to Messrs. Dunn and Crawford for the facilities given me in these trials.

* I would especially acknowledge my obligations, for courtesies and information received, to Mr. Alex. MacNab, C. E., Chief Engineer of the Nova Scotia Railway.

† A detailed Report on these experiments will be made to Mr. Carvell, during the present season, by permission of the Director of this Survey.

Trials postponed.

A number of similar trials were planned for the middle of the month of December. Mr. Hudson, General Manager of the General Mining Association, placed the railway of that company, and a fine 26-ton English coal-burning engine at my disposal, for experiments on coals of the Main and Deep seams. Trips on the Association's steamer "Dragon," for a trial of Dalhousie-pit and Cage-pit coals, were arranged for, but continued stormy weather prevented these trials until it became necessary for me to return to Montreal, when it was decided to postpone them until the coming season, during which it is intended to complete the investigations.

In all of these experiments the greatest care was taken to burn the coals as economically as possible, and in notes of the performance of the engines and furnaces, the system of minute-blanks, first instituted, I believe by Messrs. Bunning and Richardson, in their experiments (at Devonport, and on the steamer "Weardale," on North Country coals, was adopted. As my experiments are not yet complete, it is not deemed advisable to publish these notes in full, at present, and therefore, in the present Report, only an abstract of the principal facts of interest obtained is given, the detail being reserved for future reports, when the series of trials for this region shall be completed.

To my own experiments on Acadia and Intercolonial coals, are added an abstract of the experiments on Albion-Mines coal, by Prof. W. R. Johnson, in 1843-1844, for the American Government; and a variety of statements concerning the value of the different coals of this region for gas-making and other purposes, which need not be here named in detail.

TRIAL No. 1, ACADIA STEAM COAL.

Railway trial of Acadia coal.

Date:—Nov. 3rd, 1869. On Nova Scotia Railway.
Trip:—From Pictou Landing to Richmond (Halifax).
Distance:—112 miles.

DETAILS OF EXPERIMENTAL TRAIN.

Locomotive used:—No. 7, N. S. Railway.

Description.—Coal-burner altered from wood-burner. Built 1857, by Neilson & Co., Glasgow. Tender-engine, four driving-wheels, 5' in diameter; cylinder (2) 16½" diameter × 21" stroke. Has a rocking grate, (six bars 2' 9" long × 7½" wide,) hung with ½" clearance, making grate 3' 8" wide, and giving about 10 square feet fire-surface. In each bar there are sixteen openings 1½" × 7½", which, with openings between bars, and at sides and ends, give about 8½ square feet air-passage in grate. Grate is rocked by movable bar.

Experimental train.

Weight Train.

	Pounds
Engine.—The total weight of Engine No. 7, without tender is.....	66,138
(Of this 35,650 lbs. is effective weight on drivers.)	
Weight of tender, with water, without coal.....	40,340
1 supply platform-car, (coal); weight at start.....	35,330
5 box-cars, each carrying 100 barrels of flour....	181,600

6 coal (platform) cars, (loaded).....	205,090
1 first-class passenger-car	28,260
Officers and passengers	1,820
<hr/>	
Total weight of train at start	558,910
Or about	249 tons, 10 cwt.

The length of this train, from front of leading-wheels of engine, (forward truck,) to rear wheel of last car, was 457 feet.

This train started from Pictou Landing at 10h. 23m. A.M., and with lengthy stoppages to pass up-trains, at several stations, arrived at Richmond station at 9.17 P.M.

The account of actual time and stoppages is as follows :—

	H. M.
Time of train on road.....	10.54
Length of stoppages.....	4.44½
<hr/>	
Actual running time.....	6.09½

The character of the line run over, may be briefly described as being difficult for the first 39 miles, with up-grades as great as 67.58 feet to the mile; easy, from 39 miles to 52 miles; and with grades ranging from level to a rise of 50 feet to the mile, for the rest of the distance. The resistance encountered on these grades was materially increased by numerous curves, between Pictou Landing and Riversdale (39 miles), the sharpest of which was 955 feet radius; and also by several sharp curves on the line between Windsor Junction and Richmond, the sharpest of which has a radius of only 792 feet. Line passed over.

During the trip, the coal had several severe tests as a steam-producer, as for instance between mile-posts 17 and 29, where the grades range from 51.90 to 67.58 feet per mile. These grades were ascended at an average speed of 10 to 13 miles per hour, and on the steepest, (Summit grade,) 67 feet per mile, with a curve of about 1000 feet radius, the engine kept up steam well, losing only 4½ lbs. in 6 minutes, with both pumps on; * and making 59 revolutions per minute at the top of the grade.

The grate was shaken but three times; at Glengarry (24 miles), Brookfield (60 miles), and Elmsdale (83 miles). No inconvenience was felt from ash, although the engine had a tight ash-pan, until Elmsdale was reached, when the throats of the dampers, forward and back, were found to be slightly choked with ash, and were cleaned, about 20 lbs. of ash being removed. The smoke-box was also opened, and about a bushel of cinders taken therefrom, which had covered a few of the lower tubes. With an

* Pumps of Engine No. 7, are two 2" plungers; 21" stroke.

ordinary train, it is probable that neither of these cleanings would be needed, but this experimental train was, I believe, the heaviest ever run over the road.

STATEMENT OF COAL BURNT.

Coal consumed. The following is a statement of the amount of coal consumed on this trip:—

	<i>Pounds.</i>
Weight of supply-car at Pictou Landing.....	35,380
“ “ Richmond	29,530
Coal put on tender.....	5,850
Deduct coal left on tender	214
	<hr/> 5,636
Or in round numbers 2 tons, 10 cwt. = 50.3 lbs. per train-mile, or 3.87 lbs. per car-mile.	

Ash and clinker. The amount of ash and clinker from this coal was 552 lbs., or about 8.3 per cent. The ash was gray, with a reddish tint, the clinker brittle, with a flesh tint, in some places inclining to reddish. No clinker was observed adherent to the bars, and no pieces of clinker of a size exceeding three or four pounds.

Water evaporated.

The water evaporated was estimated by carefully gauging the tank of the tender at each water-station, and calculating the weight of the number of cubic feet passed into the boiler, as given by the gauge-marks. Although liable to errors, it is probable, from the number of gaugings, that these errors will nearly balance one another, and that the general totals will be correct. The following is the calculated weight of water evaporated between stations:—

	<i>Pounds.</i>
Between Pictou Landing and Glengarry. 24 miles....	10,542
“ Glengarry and Riversdale. 15 “	4,869
“ Riversdale and Pollybog..... 26 “	5,873
“ Pollybog and Windsor Junction 35 “	10,291
“ Junction and Richmond..... 12 “	3,137
Total, between Pictou and Richmond..	<hr/> 34,712

Result.

This is equal to 6.159 pounds of water evaporated, to one pound of coal burnt. The average temperature of the feed-water, for the trip, was about 40° Fahrenheit, and the evaporative power of the coal for water from this temperature being equal to 6.159 lbs., its evaporative power in pounds of water from 212° F., would equal 7.24 lbs., to one of coal.*

* This result is obtained without taking pressures of steam into consideration, which would involve a lengthy discussion of varying pressures at different points on the road. It is only an approximation.

This result, which I consider remarkably good, was obtained, not from a picked sample of the coal, but from a fair average sample of the product of the colliery. The supply-car was taken as an average of a train of ten platform-cars of coal raised at the colliery on November 2nd, the day before the trial; the weight of coal on these cars being somewhat above 100 tons.

TRIAL NO. 2, ACADIA STEAM COAL.

Date :—November 5th, 1869.—On Prince Edward Island Steam Navigation Company's steamer "St. Lawrence." Steamer-trial;
Acadia coal.

Trip :—From Pictou Landing, Nova Scotia, to Charlottetown, Prince Edward Island.

Distance :—About 59 miles.

DETAILS OF STEAMER "ST. LAWRENCE."

This vessel is a side-wheel coast steamer, of the American pattern, with saloon and promenade decks above the hull. Her tonnage, according to her papers, is as follows :— Steamer "St.
Lawrence."

	Tons.
Tonnage under deck.....	382.61
" for propelling power.....	170.53
" houses, over deck.....	463.02
Gross tonnage.....	845.63

Her dimensions are :—

	Feet.
Length, total.....	201.5
Main breadth, (amidships).....	30.2
Depth from deck.....	9.9

Her engine is a vertical-cylinder beam-engine of the American pattern. The details of engine, boiler, etc., are as follows :—

Engine.—Cylinder 44" by 11' stroke with Steven's cut-off; cutting off at 5½ feet (half stroke). (250 Nominal H. P.) Machinery.

Boiler—Compound boiler, (return flues and tubes). Breadth across three fires 13' 6"; length at furnace 8' 6"; cylindrical shell, 15' 6" long, and 11' 6" in diameter. The details of the flues are :—Outside furnaces, three flues, respectively, 10," 17", and 19" diameter; centre furnace, four 14" flues. Above these flues are 96 tubes, 17 feet long and 5" diameter.

Steam was up at the commencement of the trial, but before putting on any weighed coal the furnaces were cleaned of coal and ash, about 300 lbs. of fire being left for the start. At 11.30 A.M. 1200 lbs. of coal were put on to the fires, making in all 1500 lbs. put on before starting. The start at full speed was made at 12 h. 35 m. P.M., and the engines were then

Behaviour of
coal under mar-
ine boilers.

run at regular speed during the entire trip to Charlottetown. The panning table shows all the detail of firing and performance of the engine and gives almost all the information of value obtained during the trial. It shows the regularity with which the engines were run, and pressure of steam kept up with but little trouble on the part of the stoker. The reason for that this table is given, is that in several published reports relating to Provincial coals, it has been stated that in using these coals a great amount of trouble is given to the fireman, through the coal falling and adhering to the bars, requiring perpetual raking and slicing to keep up the fire in order to keep up a good draught. These statements are completely refuted by the notes given in the table, which shows that during the three hours commencing with 1, 2, and 3 o'clock, while the steam was running regularly, no breaking up of the fire was needed; that the fire in the three furnaces were raked only four times, and that so far from draught being obstructed, the fire-doors were frequently open for a number of minutes each hour, to admit air above the fires. The table is regarded simply as a transcript of the notes; and as no similar trial has yet been made with which the results might be compared, any discussion of these notes will be of no practical value.

Coal consumed. The weight of coal consumed upon this trial was as follows:—

	Pounds.
Left on fires at start, about.....	300
Fires banked before starting, with.....	1,200
Actually consumed during trip.....	6,441
Total.....	7,941

Grate

of which 1326 lbs., or 16.69 per cent., was ash, clinker, and unburnt coal; the unburnt coal would probably equal about 100 lbs. No clinker was observed of a size over four inches cube, and none adhered to the grate bars. The bars in the furnaces of the "St. Lawrence" had been in use for eight months, at the time of my trial, during which time Acadia coal has been burnt, and they showed no sign of fire-marks. The bars were every way in as good condition as when put in. I was informed by Mr. Turner, Chief Engineer of the P. E. I. Steam Navigation Company, that the bars in the "Princess of Wales," of the same line with the "St. Lawrence," and also burning Acadia coal, had been in for some two seasons (the running season being about eight months,) and that they were still in as good condition. The importance of these facts will be appreciated by the engineers.

The officers of the steamer St. Lawrence, are:—Master, E. I. Turner; Chief Engineer, Jas. Turner; first assistant, Arch. Livingston; to whom I am indebted for their courtesies during my experiment.

ENGINES.

[illegible]

where F indicates that the case may be an observation. Of

assisted by Mr. Thos. Lawther, of the Albion Mines, who took notes in the fire-room, of the firing and weight of coal used.

Beside the notes given in the table, minute-notes were taken, during several hours, of the smoke emitted from the funnel of the steamer, from *Smoke*. which the smoke-equivalent of the Acadia coal, as burnt in the furnaces of the St. Lawrence, appears to be about 120 ; showing that the coal is not burnt by any means as economically as is possible.*

It was first my intention to include the notes of the smoke, or *smoke-marks*, in the table of firings, but as the notes were taken by a person with but little experience in this matter, I reserve them for a future report, if corroborated by subsequent experiments.

TRIAL No. 2, WOOD.

(FOR COMPARISON WITH ACADIA STEAM COAL.)

Date:—Nov. 10th, 1869. On Nova Scotia Railway.

Trip:—From Pictou Landing to Richmond (Halifax).

Distance:—112 miles.

Railway trial of wood.

DETAILS OF EXPERIMENTAL TRAIN.

Locomotive used:—No. 19, N.S. Railway.

Description:—Wood burner by Neilson & Co., Glasgow. This engine is of the same pattern and dimensions as No. 7, and before the alterations in furnace and draught arrangements of No. 7, the two engines were precisely similar. This engine was not weighed, but the weight may be safely taken as the same as that of No. 7.

	Pounds.	
<i>Weight of Train.</i> —Weight of engine without tender.....	68,130	Experimental train.
Weight of tender with water, (without fuel).....	40,340	
5 box-cars, each carrying 100 barrels of flour.....	181,040	
7 coal (platform) cars, (loaded)	229,670	
1 first-class passenger car (same as No. 1 Trial).....	28,260	
Officers and passengers.....	1,820	
<hr/>		
Total weight of train, not including wood on tender, which amounted to $1\frac{1}{2}$ cords, or about 3 tons, 3 cwt., at start..	547,260	
Or about	244 tons, 7 cwt.	
" Add fuel, at start.....	3 " 3 "	
<hr/>		
" Total weight with fuel about.....	247 " 10 "	

*For discussions of the subject of the economical use of bituminous coals as steam-producers, see the Reports of Messrs. Richardson and Bunning, "On the experiments at Keyham, on the use of mixed Hartley (Newcastle) and Welsh coals in Marine boilers," Trans. North of England Institute of Mining Engineers, Vol. XIV; — the "Report of a Committee on the Smoke Question," Ibid., Vol. XVIII, p. 37 et seq.; and Mr. Bunning's Report on Experiments on Hartley coal, on the steamer Weardale, Ibid. Vol. XVIII, p. 105. These experiments will be again referred to, and some notes on this subject given, in the latter portion of this Section of this Report.

Or only about two tons less than the train in Trial No. 1. The length of train was, as before, 457 feet, the same number of cars of each class being used.

Trip.

This train started from Pictou Landing, at 8 h. 34 m. A.M., and after many stoppages, as before, to pass up-trains, and to allow regular down-trains to pass, reached Richmond station at 9 h. 18½ m., P.M.

The account of actual time and stoppages is as follows :—

	H.	M.
Time of train on road.....	12.	44½
Length of stoppages.....	5.	55½
Actual running time.....	6.	48½

The character of the line has already been described, under Trial No. 1 and the conditions of weather, track, etc., under which the two trials were made were as nearly as possible similar. Steam was kept up well by the engine, but with much greater labour of the fireman than during the previous trial. It is difficult to make a proper comparison between the two experiments in this particular, without a table showing the varying pressures on the different grades throughout the entire length of the line. Such a tabulation has been made in manuscript, but will not be here given, as it would necessarily extend the size of this Report. It shows no important difference between coal and wood. It has already been noted that on the Summit grade (67.58 feet to the mile, with a curve of about 1000 feet radius), the engine in the coal-trial made 59 revolutions per minute, with both pumps on. Under precisely similar conditions, the wood-engine, with a train of about two tons less weight, made 47 revolutions. Thus, in the severest test during the experiments, the coal gave the best result.

With wood, as may be expected, no attention to ash or cinder was necessary.

STATEMENT OF WOOD BURNT.

Wood consumed.

The following is a statement of the wood taken on to the tender during the trip :—

Wood taken on at Pictou Landing.....	1½	Cords.
“ “ “ “ Glengarry.. .. . 24 miles.....	½	“
“ “ “ “ Riversdale.....	38	“
“ “ “ “ Pollybog.. .. .	64	“
“ “ “ “ Windsor Junction.....	99	“
Total taken on to tender during trip.....	4	Cords.
Remaining on tender at Richmond.....	½	“
Total wood consumed on trip.....	3½	Cords.

This wood (dry), weighs about 2 tons 1 cwt. per cord; the total quantity consumed would thus amount to about 17.210 lbs., equalling 7 tons 14 cwt., nearly. This is equal to 153.66 lbs., per train-mile, or 11.88 lbs. per car-mile.

The weight of water evaporated was estimated as in the previous railway trial. The calculated amounts used between stations are:—

	Pounds.
Between Pictou Landing and New Glasgow, 8 miles.	2,761
New Glasgow and Glengarry... .. 16 "	7,831
Glengarry and Riversdale... .. 15 "	5,175
Riversdale and Pollybog... .. 26 "	7,530
Pollybog and Elmsdale... .. 18 "	5,330
Elmsdale and Windsor Junction... .. 17 "	6,024
Junction and Richmond... .. 12 "	2,886
Total between Pictou and Richmond.....	37,537

This is equal to 2.181 pounds water evaporated for one pound of wood burnt, the temperature of the feed-water being, as before, about 40° Fahrenheit. The quality of the wood used on this trial, was, in my opinion, considerably better than the average supplied to the railway; at least in a number of trips between Pictou and Halifax, I have never seen as good quality used; it was principally hard-wood, birch, etc.

COMPARISON OF COAL AND WOOD.

(DEDUCED FROM TRIALS OF ACADIA COAL AND WOOD, ON THE N. S. RAILWAY.)

In regard to length of trip, condition of track, and weight of train, the comparative trials may be said to have been made under nearly similar circumstances. The weight of train in the wood-trial was two tons less at the start than the train in the coal trial, but the amount of wood added during the wood-trial at different points, and carried varying distances, probably equalled two tons carried the entire distance. The length of stoppages during the wood-trial was 1h. 1½m. longer than in the coal experiment, which would result, though to only a small extent, in favour of coal. All things considered, however, the conditions in each were practically the same, and it now only remains to compare the results, in the most important particulars of time, labour of men, first cost and expense in use of the two fuels.

Time.—It has been remarked on the preceding page that no important difference has been shown by the notes taken of the steam-gauge during the two trials. That there must be some difference in favour of coal, in capacity for keeping steam, will be seen by a comparison of actual running time, which stands as follows:—

	H.	M.
Actual running time, wood trial.....	6	48½
“ “ coal trial.....	6	09½
Difference in favour of coal.....	0	39

A saving of time might be effected if coal were used, from the fact that enough coal might be put on to the tender at the start from either terminus of the railway, for the entire trip. This could not be done in using wood, for several reasons:—first, because the capacity of the tender would not be sufficiently great; and second, even if the tender were of sufficient capacity, the great weight carried, (7 or 8 tons of wood, to say nothing of the greatly increased weight of tender,) would be a material objection.

Time lost in
wooding-up.

In the first of the experiments under consideration, the greater part of the coal consumed was put on the tender at Pictou Landing, a small portion being added from the supply-car during the last 25 miles. As the entire quantity *might* have been added, without inconvenience, at the start, we may assume that no time was lost in coaling.

During the second trial, the record of time consumed in *wooding-up* stands as follows:—

At Glengarry.....	3 men employed in wooding	9 minutes.
“ Riverdale.....	3 “ “	7 “
“ Pollybog.....	2 “ “	6 “
“ Windsor Junction..	3 “ “	5 “

Total time employed in wooding..... 27 minutes.

As it was generally known along the line that this train was an experimental one, it is but reasonable to suppose that, at least, the usual celerity in wooding was attained. The account includes only the actual time employed in throwing the wood on to the tender. Probably several minutes might be added for time consumed in getting the train in position at the wooding-station, starting, etc. If we suppose this extra time to amount to three minutes, we then have one half hour of time lost in taking in wood, between Pictou and Halifax.

about.

Labour of men.—It will be evident from the last paragraph that a considerable amount of labour would be saved at the various stations were all the fuel for a trip carried from each terminus. This, however, properly comes under the head of expenses, and the only point to be here considered is the difference in labour of the fireman, which is very considerable, as will be seen by a comparison of the two fuels burnt:—coal, 5,636 lbs.; wood, about 17,210 lbs.; divided into, respectively, 76 and 136 firings.

Comparative
expense.

Comparative expense.—Not being connected with this railway, I have no means of estimating, except in the rudest manner, the comparative

expense in the use of the two fuels. An approximate idea can be gained by a moment's consideration of the general management required to supply trains at the termini, and at various points along the road.

Wood.—After being cut, the wood is generally corded at or near some point on the main line, from whence it is taken on extra wood-trains to the different wooding-stations, to be used as need be. This not only requires many extra hands, but extra trains, with consequent wear and tear of rolling-stock and permanent way.

Coal.—With coal, but two coaling-stations would be required; at Pictou and Richmond (Halifax). The coal could be put into coal-cars at the mines, for transportation to the two termini, or, should a third station be required, to Truro also. At these stations a system of shutes could be arranged, by means of which the coal could be put into the tender very quickly, and without any handling. I shall not attempt to estimate the cost of running the line, but for general information it may be stated that the cost of coal, delivered at Coal Mines station, is about \$2.25 per ton, (or, say \$2.50 at Pictou Landing, and \$3.00, without profit in carriage, at Halifax;) while the contract price of wood is, I believe, \$3.50 per cord, delivered at the wooding stations. During about eight months in the year two regular passenger and freight trains are run each way per day, on this railway, between Pictou and Halifax, and two each way between Truro and Halifax (61 miles); to say nothing of the extra and coal trains. During the winter months, only one through-train is run, each way, per day.

TRIAL NO. 4; DRUMMOND COAL.

This trial was made on December 2nd, 1869; a previous trial, in the latter part of the month of November, having been abandoned on account of bad weather. The length of the Intercolonial Coal Mining Company's railway (about $6\frac{1}{2}$ miles) not being sufficient for a proper trial with a single trip; three round trips (from the colliery to the Drummond wharf at Granton, and back— $13\frac{1}{2}$ miles) were made with a loaded coal train. During these trials the usual careful notes were taken of the performance of the engine, and the line being staked out in miles and half-miles, the time of passing the stakes, as well as a number of other points on the road, were also taken, to a second, by Mr. William Crawford, C.E., Chief Engineer of the Intercolonial Company, who kindly accompanied me, and to whom I would express my obligations for the interest he has taken in my experiments, and the valuable aid he has afforded me.

The notes of this trial furnish a complete record of the performance of the engine upon each grade, and when time permits they will be given to the public, with a proper discussion of the facts elicited.

For the purpose of the present Report, however, it will be sufficient to

give the general results, and the trial will be divided into two experiments; the first, (experiment A), from an improper arrangement of the ash-pan and grate-bars, not having been as successful as the second (experiment B). The same train was used in both.

Description of line.—The down-trip from the colliery to Granton was comparatively easy, as it included only about one and a-half miles of up-grade, ranging from 44 feet to 53½ feet per mile. The average grade on the return-trip was about 50 feet up, per mile, for the first three miles; down about 45 feet per mile, for one and a-half miles, and then up, with grades ranging from 23½ feet to 98 feet per mile, and averaging, perhaps 65 feet per mile. Some of the curves were very sharp; one of 100 feet radius, and one more than one-quarter of a mile long of 655 feet radius, besides a number ranging from 702 feet to 1,433 feet radius.

DETAILS OF TRAIN IN BOTH EXPERIMENTS.

Locomotive used :—No. 3, Intercolonial Coal Mining Company's Railway.

Description :—Coal burner by Dübs & Co., Glasgow, Scotland—Tank-engine, six cylinders, 5' diameter (coupled). Cylinders (2) 14" diameter × 22" stroke,—with 75 per cent. of steam on piston when in full gear. Firegrate area 12.12 square feet. 152 brass tubes, 1½" outside diameter—superficial area of which is 680.48 square feet. Wheel-base of engine, 11 feet.

	Tons.	cwt.
Weight of Train.—Weight of engine No. 3, empty.....	20	0
Equipment	5	0
12 coal cars, loaded, (75 tons coal).....	116	17
Officers and passengers.....	0	7
Total weight of train	142	4

The length of this train from tread of forward driver was 196 feet.

The coal consumed was carefully weighed on a Fairbanks scale, and the water evaporated estimated as in previous trials. The two tanks of the engine were rectangular, and being exactly filled each time of taking-in water, the estimate of water may be relied upon.

EXPERIMENT A.

In this experiment the grate-bars in the furnace of Engine No. 3 were not properly arranged, every other grate-bar having been removed, leaving about 2 inches between the bars, through which a considerable amount of unburnt coal fell, choking up the dampers of the ash-pan (which was very small), and thereby obstructing the draught. Added to this, the day was so intensely cold that the steam-gauge was frozen on the up-trip, and the

fires could not be properly regulated. The record of distance, time, etc., is as follows :—

Trip 1. Down to wharf at Granton.....	distance 6.60 miles.	Distance.
" 2. Back to upper siding at colliery	" 6.84 "	
Total distance; round trip.....	13.44 miles.	
	Min. Sec.	
Trip 1. Time on road, no stoppage.....	24 46	
" 2. " " " 52 m. 20 s. stoppage 18 m., actual time...	34 20	Time.
Actual running time (13.44 miles)	59 06	

During experiment A, trip No. 2, the steam-gauge was frozen, and the fire could not be properly managed ; the 18 minutes stoppage was time lost in thawing the gauge, and getting up steam with the blower, while standing.

STATEMENT OF COAL BURNED AND WATER EVAPORATED.

The amount of coal burnt, while running and during stoppage, was 658 Results. lbs ; the water evaporated being 3,423 lbs. This is equal to 5.202 lbs. of water, evaporated from the temperature of the feed water, (about 35° F.), to the pound of coal consumed, or 6.15 lbs. of water evaporated from 212°, to one pound of coal, not taking pressures of steam into consideration. The coal was divided into 12 firings ; 3 on the down-trip and 9 on return-trip to the colliery. The fire-door was open 9 minutes on the down-trip and 7 minutes on the return. The engine was on a down grade 18 minutes, during the down trip (and not using steam), and about 4 minutes during the return. The fire was broken up with the pricking-bar, once on each trip, which was all the attention it required, save firing. The coal steamed well, except at the close of the second trip, when the ash-pan damper became choked with ash and unburnt coal, (the engine being designed for Scotch coal, which gives very little ash.)

EXPERIMENT B.

This trial was far more successful than the first, as the full set of bars Second trial. were put in, leaving spaces of but $\frac{3}{4}$ of an inch between them. The ash-pan was removed, and the steam-gauge properly protected. Four trips (or two round trips) were made with the same train as in experiment A. The record of distance, time, etc., is as follows :—

Trip 3. Colliery to wharf.....	distance 6.65 miles.	
" 4. Wharf to upper siding at colliery.....	" 6.80 "	
" 5. Upper siding to points near wharf.....	" 6.62 "	Distance.
" 6. Wharf to upper siding at colliery.....	" 6.74 "	
Total distance; four trips.....	26.81 miles.	

						H. Min. Sec.
Time.	Trip 3.	Time on road	27m. 40s.,	stoppage	4m. 15s.,	actual time...0 23 25
	" 4.	" " "	35m. 00s.,	"	7m. 38s.,	" " ...0 27 22
	" 5.	" " "	21m. 05s.,	no stoppage		" " ...0 21 05
	" 6.	" " "	41m. 25s.,	stoppage	8m. 10s.,	" " ...0 33 15
		Actual running time, (26½ miles).....				1 45 07

STATEMENT OF COAL BURNT AND WATER EVAPORATED.

Results. Steam being up at the commencement of this experiment, the amount of coal consumed was 1,236 lbs., during the four trips. The amount of water evaporated was 8,253 lbs.; thus the result was:—6.67 lbs. of water evaporated from 35° F., by one pound of coal, equal to 7.69 lbs. evaporated from 212°, without taking steam-pressures into consideration. This result not only proves the coal to be an excellent steam-coal for locomotive use, but also indicates that the coal was very economically burnt by the locomotive. In comparing this result with the results of railway trial No. 1, of Acadia coal, the fact should be taken into consideration that the result in the Drummond coal-trial was obtained with an engine built expressly for burning this class of bituminous coals, whereas the engine used in the Acadia steam-coal trial was a wood-burner, but slightly altered, and in all probability not burning the coal in the most economical manner.

The notes of the second experiment (B) give the following facts, which are, perhaps, worthy to be included here:—During the four trips, the number of firings was 17; the fire-door was open for draught above the grate, 62 minutes; and the engine was on an up-grade—or using steam—during 81 minutes.

Ash of coal The ash from the coal burnt was gray, with a faint reddish tinge. The coal clinkered somewhat, but no inconvenience was felt from that cause, as the clinker did not adhere to the grate bars.

Portion of seam used. The coal used was believed to be a fair average of the 16 feet of the seam worked; being a mixture of all the benches except the *top-coal* and *coarse-coal* at the bottom of the seam.

AMERICAN NAVY TRIALS OF PICTOU COALS.

American coal-trials by Prof. Johnson.

In a very complete series of trials undertaken for the American government by Professor W. R. Johnson, in 1843 and 1844, were included experiments on two samples of Pictou coals, both from the Old Albion mines, and taken, I believe, from the upper twelve feet of the Main seam. These experiments were conducted with the greatest care, and with the exception of the British experiments, made by Sir Henry T. De la Beche and Dr. Lyon Playfair, for the Lords Commissioners of the Admiralty, the

American trials are probably the most complete and accurate series of trials of steam-coals ever made.

As the results of Professor Johnson are of great value to the consumers of Pictou coals, I shall take the liberty of including an abstract of them in this Report, especially as the volume in which they are contained ("Report to the Navy Department of the United States on American coals applicable to Steam Navigation, etc.," by Walter R. Johnson,) has been for years out of print. Report of Prof. Johnson.

The boiler employed in these experiments was 30 feet long and $3\frac{1}{2}$ feet in diameter; set over a furnace, and the heated gases after passing from the fire through two interior return-flues, each of 10 inches interior diameter, escaped either through an opening, known in the Report as the *lower damper*, into the chimney, or when this damper was closed, it ascended from the ends of the two return-flues into an exterior flue on the *left* of the boiler, and passed along this once more to the rear of the boiler, crossed the end, and entered a *right hand* exterior flue, by which, through the *upper damper*, it arrived at its exit into the chimney, entering the latter at a level only 14 inches higher than when it passed by the direct exit-flue to the lower damper. The details of heating-surface, and lengths of flues traversed, together with the arrangements for heating the air before passing through the grate, are given in the following quotation from Professor Johnson's report. It follows the detailed description of the boiler and flues, a partial abstract of which I have just given:— Apparatus employed.

"From this description, it will be observed that the air which supplies the combustion, passes first into a chamber beneath the ash-pit, about 7 feet long, and 3 feet 3 inches wide, along the sides of which are several openings, by which it finds its way into the two longitudinal side chambers, 30 feet long, 6 feet high, and 9 inches wide, between the two side walls; and having arrived, by these, at the rear of the boiler, passes 25 feet beneath the flue, arriving at the *centre* of the grate after a course of 60.5 feet. Thence a course of 58.5 feet brings the products of combustion to the aperture through the passage, by the lower damper, into the chimney; and of 62.5 feet farther, or 121 feet from the centre of the grate, to the point where they finally quit the boiler by the exterior flue. The part of the lower arch of the boiler, exposed to the action of heat, is 130 square feet, and that of the two return-flues is 157 square feet; so that when the combustion was conducted by allowing the products to make their exit through the lower passage, or after passing twice the length of the boiler, the heated surface was 287 square feet. The boiler-surface exposed in the exterior flue, or second circuit, is 90.5 feet; making the entire surface, when the products traversed four times the length of the boiler, 377.5 square feet. The grate being 5 feet long, and 3 feet 3 inches wide, when Draught arrangements.

Surfaces.

Grate.

at its full dimensions, its area was 16.25 square feet; and the ratio of the grate surface to the heated surface, when the combustion was carried on through the lower damper, was 1 : 17.66; when through the upper damper, making the circuit 121 feet long, this ratio was 1 : 23.23.

Air-plate
bridge.

"When the air-plate bridge was introduced, it covered 8 inches of the length of the grate, reducing its area to 14.07 square feet, and increasing the ratio of heated to grate surface to $1\frac{1}{4} : 1\frac{1}{4} = 26.83$ to 1.

Coking-plate.

"During a few trials the grate was still farther reduced in area, by the introduction at the front end, next to the fire-doors, of a plate of iron 3 feet 3 inches long, $11\frac{1}{4}$ inches wide, and one-fourth of an inch thick. This is termed the "*coking-plate*," and was used while burning some of the samples of bituminous coal, which were so fine that large portions were liable to pass through the grate. With this plate in place, and the air-plate in its usual position, the size of the grate was reduced to 11.375 square feet, and the heated to the grate surface increased to $1\frac{1}{4} : 1\frac{1}{4} = 33.18$ to 1.

"On one occasion, instead of contracting the area of the grate by means of the coking plate, it was diminished by placing a row of bricks flatwise along each side of the furnace, reducing the grate surface to 10.291 square feet, and the ratio of heated to grate surface to $1\frac{1}{4} : 1\frac{1}{4} = 36.68$ to 1.

Depth of fire.

"The grate was, in general, about 9 inches at the front, and 10 inches at the back end, below the lower arch of the boiler. On one or two occasions, however, which are noted in the tables of experiments, it was varied a little from this distance; but as no advantage appeared to attend the change, it was restored to this, as the most convenient working distance for all the varieties of fuel employed.

Grate-bars.

"The grate-bars used were three-fourths of an inch thick, and the space between them half an inch wide. They were supported at the centre, as well as at each end, by a cast-iron bar $2\frac{1}{2}$ inches thick, and 4 inches deep. Hence, when the grate was at its full size, the total amount of air passage through the grate was nearly $5\frac{1}{4}$ square feet.

Capacity of
boiler.

"The interior capacity of the boiler was such as to contain, when filled to the centre of the gauge-tube, or *normal* level of the experiments, with water of 66° temperature, 12,795 lbs. This is the result of an experiment made after clearing out and wiping dry the interior of the boiler, and refilling it through the measuring-cistern. Of this quantity, 493 pounds were then withdrawn, leaving 12,302 pounds, filling the boiler to within 1.1 inch of the normal level. On subsequently heating this to 230° , the water in the gauge, after taking all due precaution to withdraw the cold water from the glass tube, and filling it with that which was hot, stood once more at the normal level. Hence the apparent expansion of water in iron, by an addition of 164 degrees of heat, is equivalent to $1\frac{1}{4} : 1\frac{1}{4} = 0.0407$, or a little more than one twenty-fifth part of its bulk at 66° ."*

* Report on American Coals, pp. 12-13.

The details of supply of water, gauges and discussions of the method of conducting the experiments, though of very great scientific interest, occupy too much space to be given here. I shall therefore proceed to the results of the experiments, using as nearly as possible the arrangement of the original report. All the facts which follow, are taken from Johnson, and where advisable, his report is quoted *verbatim*. Other details omitted.

Under Class IV, (p. 452) of the Report, Professor Johnson includes : Classification of Pictou coals.
 "Foreign bituminous coals, and those of similar constitution West of the Alleghany Mountains." Among the foreign coals, he includes :—

1. Pictou, (purchased in New York.)
2. Sydney.
3. Pictou, (Cunard's.)
4. Liverpool.
5. Newcastle.
6. Scotch.

Johnson's Class IV.

In description of the general characters of these coals, he says :—"In many respects this class of coals bears a strong analogy to the preceding.* The ratio of the fixed to the volatile combustible matter is, however, something less. The exterior presents often a resinous lustre. The surfaces of deposition are easily developed by fracture. Great facility of ignition and a high degree of activity in the combustion of their volatile constituents, are also general properties of this class. Their high proportion of volatile combustible matter renders these coals, when nearly free from sulphur, eminently suitable for the production of illuminating gas ; and the tendency of their cokes, with few exceptions, to intumesce strongly, renders them, in common with the preceding class, highly serviceable for forming large hollow fires for smithing purposes." General characters.

(Copy.)

No. 1.

Bituminous coal from Pictou, Nova Scotia, procured from Messrs. Laing & Randolph, in New York, for comparative experiments.

This coal has a glimmering lustre, or a dull aspect, according to the part observed. The surfaces of deposition are, in some specimens, inclined at an angle of 83° to the main partings ; thin scales of earthy matter are occasionally found in the joints, or vertical seams ; but, in general, little impurity is observable on the exterior. Conchoidal fractures are of unfrequent occurrence. The coal was of average size, lumps and fine being intermixed in due proportion, to constitute a merchantable article for ordinary use in smith's fires, and for domestic purposes. The Trial of the coal bought in New York.

* Class III. Bituminous coking coals from the eastern coal-fields of Virginia in the neighbourhood of Richmond. (Report, pp. 308-541.)

powder of this coal is of a dark brown colour, and its streak on a white earthen ground is of the same tint.

The specific gravity of one specimen (*a*) was 1.3546; that of another (*b*) 1.2807: from the mean of which, the calculated weight per cubic foot is 82.85 pounds.

By 39 trials in the charge-box, the greatest weight of any one charge was 112.25 pounds, or 56.125 lbs. per cubic foot. The least weight was 97.5 lbs. per charge, or 48.75 lbs. per cubic foot; while the average of the whole was 53.548, or 0.6502 of the above calculated weight. The space for the stowage of one ton of the coal is 41.832 cubic feet.

The moisture in specimen *a* was 0.97; and that in *b*, 0.935 per cent.

The volatile matter, other than moisture, in *a*, was 27.51; the sulphur, 0.7689 per cent.

The volatile matter, other than moisture in *b*, 20.105.

Four incinerations of *a*, gave of *ashes* 2.38; and the same number of *b*, 2.65 per cent. Hence the composition is as follows, viz:—

	Specimen <i>a</i> .	Specimen <i>b</i> .
Moisture.....	0.970	0.935
Sulphur.....	0.769	(not tried.)
Other volatile matter.....	26.741	20.105
Earthy matter.....	2.380	2.650
Fixed carbon.....	69.140	76.310
	100.	100.

The volatile to fixed combustible..... 1 : 2.5132 1 : 3.7955

Two specimens of this sample of coal were assayed by Dr. King, and yielded, the one 36, and the other 33, per cent. of volatile matter, including moisture. These, combined with the above, give a mean of 29.63, which may probably be assumed as a pretty near approximation to the average yield of this ingredient.

By exposure for four days in the steam-drying apparatus, 28 pounds of this coal lost 0.71875 lbs. of moisture, or 2.567 per cent.

During the four trials of evaporative power, 4153.875 pounds were burned, and yielded 302.4 lbs. of ashes, (including those of 408.62 lbs. of pine wood,) 253.475 pounds of clinker, and 19.5 pounds of soot. The ashes lost by re-incineration 5.907, and the soot 65.42, per cent. of their weight.

Hence the absolutely incombustible materials are—

From the ashes.....	284.540 pounds.
“ clinker.....	253.475 “
“ soot.....	6.743 “
Total.....	544.758 “
Deduct for wood ashes.....	1.227 “
Leaves.....	543.531 “

which is 13.389 per cent. of the coal burned.

By these data we may assign the following as the proximate constituents of this sample, viz. :—

Moisture, (from 28 lbs.).....	2.567 per cent.	
Other volatile matter, (mean of 4 specimens).....	27.063	"
Earthy matter (from 4153.87 lbs.).....	13.389	"
Fixed carbon.....	56.981	"
	<hr/>	
	100.	

Volatile to fixed combustible ... 1 : 2.1054

The above result in earthy matter, derived from a sample of two tons, exhibits a striking contrast with the analyses of single hand-specimens.

The clinker is of a dark reddish-brown colour, in sheets of considerable magnitude, somewhat porous; small shaly fragments are intermixed, and sometimes adhere to the vitrified masses. It weighed 43.12 pounds per cubic foot, and gained weight by calcination equal to 0.84 per cent., leaving the powder of a light brown, with its finer parts bright red.

The weight of the ashes, as they came from the furnace, was 38.56 lbs. per cubic foot; and the residue of their re-incineration had a colour nearly flesh-red, while that from the soot was reddish-grey—a shade lighter than that from the ashes.

The ashes from specimens *a* and *b* are of a purplish-red colour, with specks of white.

Tried with the oxide of lead, 20 grains of specimen *a* gave 544.8 grains of metallic lead, or 27.24 times its weight. Deducting moisture and earthy matter, this gives to one of combustible matter 28.184.

In a smith's fire for ordinary work, this coal afforded a rather dull combustion; made a good hollow fire; left a fair coke, not unusually hard; produced a large quantity of cinder, and gave a tolerably fair heat.

In the chain-shop, it gave a heavy flame; formed a coke too hard to be easily broken up, as the work requires; was rather hard and unmanageable, and left a large proportion of cinder. Sixty pounds made but 11 links of a chain 1½ inch in diameter; while several other coals, tried by the same workman on the same chain, were found adequate to the making of from 13 to 20 links, by the same weight of coal.

Trial for chain making.

The ignition of this coal is easily effected. It took, on an average of four trials, only 0.937 hour, or 56½ minutes, to bring the boiler to a state of steady action. In conformity with this fact, is that relative to the unburnt coke, which was, on an average, only 5.689 lbs. at each trial.*

* Here follow tables giving the details of all the experiments; from which the deductions in the table on the next two pages are taken. It is extracted *verbatim* from Johnson's Report.

DEDUCTIONS FROM TABLES CLV, CLVI, CLVII.

. Experiments on Picous

Nature of the data furnished by the respective tables.		1st Trial. (Table CLV.)	2d Trial. (Table CLVI.)
		August 30.	August 31.
1	Total duration of the experiment, in hours.....	22.033	23.95
2	Duration of steady action, in hours.....	6.333	6.333
3	Area of grate, in square feet.....	14.07	14.07
4	Area of heated surface of boiler, in square feet.....	377.5	377.5
5	Area of boiler exposed to direct radiation, in square feet.....	18.75	18.75
6	Number of charges of coal supplied to grate.....	9.0	10.0
7	Total weight of coal supplied to grate, in pounds.....	978.50	1071.75
8	Pounds of coal actually consumed.....	974.88	1069.612
9	Pounds of coal withdrawn and separated after trial....	3.62	2.138
10	Mean weight, in pounds, of one cubic foot of coal.....	54.361	53.5875
11	Pounds of coal supplied per hour, during steady action.....	120.77	119.69
12	Pounds of coal per square foot of grate surface, per hour.....	8.583	8.506
13	Total waste, ashes and clinker, from 100 pounds of coal.....	13.714	12.934
14	Pounds of clinker alone, from 100 pounds of coal.....	6.6911	6.2139
15	Ratio of clinker to the total waste, per cent.....	48.788	48.0695
16	Total pounds of water supplied to the boiler.....	7759.0	8340.0
17	Mean temperature of water, in degrees Fahrenheit.....	82°.8	83°.0
18	Pounds of water supplied at the end of experiment, to restore level.....	782.0	550.0
19	Deduction for temperature of water supplied at the end of experiment, in pounds.....	99.0	69.0
20	Pounds of water evaporated p. hour, during steady action.....	882.36	908.88
21	Cubic feet of water per hour, during steady action....	14.12	14.54
22	Pounds of water per square foot of heated surface per hour, by one calculation.....	2.337	2.407
23	Pounds of water per square foot, by a mean of several observations.....	2.347	2.397
24	Water evaporated by 1 of coal, from initial temp. (a) final result.....	7.858	7.733
25	Water evaporated by 1 of coal, from initial temp. (b) during steady action.....	7.301	7.5936
26	Pounds of fuel evaporating one cubic foot of water....	7.9537	8.0823
27	Mean temperature of air entering below ash-pit, during steady pressure.....	92°.59	92°.31
28	Mean temp. of wet-bulb thermo., during steady pressure.....	79°.08	80°.69
29	Mean temperature of air, on arriving at the grate.....	254°.92	259°.125
30	Mean temp. of gases, when arriving at the chimney....	301°.25	334°.6
31	Mean temperature of steam in the boiler.....	229°.54	229°.5
32	Mean temperature of attached thermometer.....	84°.88	86.94
33	Mean height of barometer, in inches.....	30.161	30.079
34	Mean number of volumes of air in manometer.....	5.225	5.210
35	Mean height of mercury in manometer, in atmospheres.....	0.5342	0.5366
36	Mean height of water in syphon draught-gauge, in inches.....	0.2907	0.3077
37	Mean temperature of dew-point, by calculation.....	75°.9	77°.523
38	Mean gain of temp. by the air, before reaching grate...	162°.61	166°.535
39	Mean difference between steam and escaping gases....	71°.71	105°.1
40	Water to 1 of coal, corrected for temperature of water in cistern.....	7.8258	7.7013
41	Water to 1 of coal, from 212°, corrected for temperature of water in cistern.....	8.8059	8.6658
42	Pounds of water, from 212°, to 1 cubic foot of coal....	478.74	464.38
43	Water, from 212°, to 1 pound of combustible matter of the fuel.....	10.2055	9.9532
44	Mean pressure, in atmospheres, above a vacuum.....	1.4213	1.4288
45	Mean pressure, in pounds p. sq. inch, above atmosphere.....	6.2219	6.3324
46	Condition of the air-plates, at the furnace-bridge.....	Open.	Closed.
47	Inches opening of damper, (U. upper).....	U. 8	U. 8.

CLVIII, OF JOHNSON'S REPORT, PAGES 456-463.

coal (from New York.)

3rd Trial. (Table CLVII.)	4th Trial. (Table CLVIII.)	Averages.	Remarks.
<i>September 1.</i>	<i>September 2.</i>		
23.95	23.05		
10.00	7.083		
14.07	14.07		
377.5	377.5		
18.75	18.75		
11.0	9.0		
1179.5	947.0		
1166.61	942.89		
12.89	4.11	5.6895	
53.614	52.611	53.5434	
96.9	104.01	110.342	
6.887	7.392	7.842	
13.195	13.642	13.3712	
5.2321	6.3657	6.1257	
39.651	46.658	45.7916	
8743.0	6661.0		
84°.1	82°.7		
575.0	547.0		
72.0	69.0		
721.9	684.59	799.432	
11.55	10.953	12.7908	
1.912	1.813	2.1172	
1.893	1.794		
7.432	7.009	7.508	With damper drawn 8 inches, the first trial gave, with a clean surface of boiler and flues, and the air-plate open, 7.858 of water to 1 of coal; the second, with the same plate closed, and surfaces with one day's impurity on the flues, 7.733, or 1.6 per cent. less.
7.449	6.5802	7.231	
8.4096	8.9171	8.3407	
89°.8	90°.33		
79°.21	78°.87		
282°.05	278°.8	268°.724	
315°.42	306°.71	308°.702	
231°.0	228°.6		
85°.71	83°.0		
30.080	30.104		
5.227	5.247		
0.5343	0.5323		
0.2845	0.2443	0.2618	
75°.53	75°.7		
191°.72	189°.0	177°.466	
85°.33	77°.77	84°.69	
7.4009	6.9803	7.4771	
8.3207	7.8545	8.4117	
446.10	413.23	450.612	
9.5655	9.0953	9.7099	In the fourth trial, the decided inferiority of effect to the preceding is probably to be ascribed to the coating of soot upon the flues, and the want of sufficient draught to burn completely the products of combustion.
1.4219	1.4123	1.421	
6.231	6.0876	6.2182	
Open.	Closed.		
U. 4.	U. 4.		

GEOLOGICAL SURVEY OF CANADA.

(Copy.)

No. 3.

ious coal from Pictou, Nova Scotia, sent by Mr. Cunard, agent of the General Mining Association of London.

oal of this sample is, in every external character, entirely similar to n the same mining district obtained from New York. The specific of one specimen (a) was 1.3155; that of another, (b,) 1.3352. in of these makes the weight of the cubic foot in the solid state pounds. The actual weight, determined by 20 trials in the charge- or the least 45.5, for the greatest 52.125, and for the average unds per cubic foot, or 0.5945 of the calculated weight. Hence e to receive one ton is 45.482 cubic feet.

moisture expelled by thoroughly drying specimen b was 1.079. oking of a caused a loss, including moisture, of 26.413 per cent. cess having been conducted very slowly, the powder did not agglutinated; but another portion of the same powder suddenly to a bright red heat, became converted into a well-formed mass. men b, a portion coked so slowly, and at so low a heat, that the not take fire, exhibited a loss of 27.1 per cent. Another portion of powder, coked rapidly, so as to become completely coalescent, 4 per cent.

arthy matter in a was 10.09, in b 11.404 per cent. Hence the te constituents of these two specimens are—

	Specimen a.		Specimen b.
moisture.....(not separately determined)			1.079
olatile matter.....	26.413	other than } moisture }	26.021 { by slow coking.)
arthy matter.....	10.090		11.404
ixed carbon.....	63.497		61.496
	<hr/> 100. <hr/>		<hr/> 100. <hr/>
olatile to fixed combustible	1 : 2.404		1 : 2.3633

moisture expelled from 28 lbs., dried in the steaming-apparatus, d to 0.7812 per cent. The volatile matter, including moisture, mean of the two specimens above given, is 26.756.

g the two experiments on evaporation, there were burned 1962.5 of this coal, and the—

Weight of ashes withdrawn was.....	116.00 lbs.
of clinker.....	121.75 "
of soot.....	8.75 "

The ashes lost 0.04077 of their weight, and the soot 0.60144, by re-incineration. Reducing the weights of these two, and deducting 1.029 lbs., for the ashes of 355.25 lbs. of pine wood, we have left 245.481 lbs., for the total waste from the above weight of coal, or 12.508 per cent.

From these data it would seem that the coal is composed of—

Moisture, (from 28 lbs.)	-	-	0.7812
Other volatile matter, (from two specimens)	-	-	25.9753
Earthy matter (from 1962.5 lbs.)	-	-	12.5085
Fixed carbon, (calculated by difference)	-	-	60.7350
			<hr/> 100. <hr/>

Practical analysis.

Volatile to fixed combustible 1 : 2.5929.

The ashes weighed 39.01 lbs. per cubic foot.

The clinker " 38.00 " "

The soot " 3.82 " "

When re-incinerated or calcined, the clinker became of a dark drab or light brown colour, the ashes of a light reddish-gray, and the residue of the soot a light drab colour. The ashes from analysis of *a* were pure white ; from *b*, dirty white.

The clinker, as it came from the furnace, was black, vitreous, and porous, in masses tolerably friable, and not apparently prone to adhere to the grate. Much shaly matter attaches itself to the vitrified portions.

With the oxide of lead, specimen *b* gave 23.355 times its weight in metallic lead. Deducting moisture and earthy matter, we have left 0.87517 of combustible ; by which, dividing the above, we get $\frac{23.355}{26.686} = 0.87517$.

For the reason assigned in regard to the preceding sample which accompanied this, the trial in smith's forges and in open grates was necessarily dispensed with. This is the less to be regretted in the present instance, as the sample of Pictou coal already described has been tested in the forge ; and as the action of the two samples is in other respects almost identical, there is no reason to doubt that in this particular also they would be found to coincide.

The mean time required to bring the boiler to a steady rate of evaporation was 0.85 hour, or 51 minutes. The weight of coke left unburnt on the grate was very small, being on the first trial, 5 pounds, and on the second 2.5. The combustion commenced promptly, and the flame was long, and accompanied by considerable smoke. The large amount of clinker (more than 50 per cent. of the total waste) rendered it necessary to remove the heavier masses within a few hours after the fire was kindled.

DEDUCTIONS FROM TABLES CLXIII, CLXIV

Experiments on

		Nature of the data furnished by the respective tables.	1st Trial. (Table CLXIII)	2d Trial. (Table CLXIV)
			September 27.	September 28.
Results of Trial. No. 3. Class IV.	1	Total duration of the experiment, in hours.....	25.083	24.383
	2	Duration of steady action, in hours.....	5.267	5.333
	3	Area of grate, in square feet.....	14.07	14.07
	4	Area of heated surface of boiler, in square feet.....	377.5	377.5
	5	Area of boiler exposed to direct radiation, in square feet.....	18.75	18.75
	6	Number of charges of coal supplied to grate.....	10.0	10.0
	7	Total weight of coal supplied to grate, in pounds.....	992.25	977.75
	8	Pounds of coal actually consumed.....	987.25	975.25
	9	Pounds of coal withdrawn and separated after trial...	5.0	2.5
	10	Mean weight, in pounds, of one cubic foot of coal.....	49.6125	48.8875
	11	Pounds of coal supplied per hour, during steady action.....	149.212	127.648
	12	Pounds of coal per square foot of grate surface, per hour.....	10.6	9.072
	13	Total waste, ashes and clinker, from 100 pounds of coal.....	11.62	12.505
	14	Pounds of clinker alone, from 100 pounds of coal.....	5.7655	6.6199
	15	Ratio of clinker to the total waste, per cent.....	49.347	52.935
	16	Total pounds of water supplied to the boiler.....	7545.0	7204.0
	17	Mean temperature of water, in degrees Fahrenheit.....	70° 5	67° 3
	18	Pounds of water supplied at the end of experiment, to restore level.....	270.0	406.0
	19	Deduction for temperature of water supplied at end of experiment, in pounds.....	37.0	57.0
	20	Pounds of water evaporated p. hour, during steady action.....	1122.86	936.68
	21	Cubic feet of water per hour, during steady action.....	17.96	14.987
	22	Pounds of water per square foot of heated surface per hour, by one calculation.....	2.974	2.481
	23	Pounds of water per square feet, by a mean of several observations.....	2.988	2.498
	24	Water evaporated by 1 of coal, from initial temp. (a) final result.....	7.6049	7.328
	25	Water evaporated by 1 of coal, from initial temp. (b) during steady action.....	7.522	7.338
	26	Pounds of fuel evaporating one cubic foot of water....	8.2174	8.529
	27	Mean temperature of air entering below ash-pit, during steady pressure.....	64° 15	64° 33
	28	Mean temp. of wet-bulb thermometer, during steady pressure.....	55° 08	55° 8
	29	Mean temperature of air, on arriving at the grate.....	209° 15	233° 13
	30	Mean temp. of gases, when arriving at the chimney....	296° 0	330° 0
	31	Mean temperature of steam in the boiler.....	231° 0	232° 0
	32	Mean temperature of attached thermometer.....	62° 115	59° 67
	33	Mean height of barometer, in inches.....	30.146	30.249
	34	Mean number of volumes of air in manometer.....	5.0246	5.004
	35	Mean height of mercury in manometer, in atmospheres.....	.5546	.5572
	36	Mean height of water in syphon draught-gauge, in inches.....	.3241	.3525
	37	Mean temperature of dew-point, by calculation.....	46° 78	48° 63
	38	Mean gain of temp. by the air, before reaching grate..	145° 0	168° 8
	39	Mean difference between steam and escaping gases....	67° 66	107° 06
	40	Water to 1 of coal, corrected for temp. of water in cistern.....	7.5864	7.3148
	41	Water to 1 of coal, from 212°, corrected for temperature of water in cistern.....	8.6249	8.3446
	42	Pounds of water, from 212°, to one cubic foot of coal..	427.9	407.94
	43	Water, from 212°, to one pound of combustible matter of the fuel.....	9.7589	9.5373
	44	Mean pressure, in atmospheres, above a vacuum.....	1.4389	1.4408
	45	Mean pressure, in pounds p. sq. inch., above atmosphere.....	6.4819	6.5104
	46	Condition of the air-plates at the furnace-bridge.....	Closed.	Open.
	47	Inches opening of damper, (U. upper).....	U. 8.	U. 8.

OF JOHNSON'S REPORT, PAGES 478-481.

Pictou (N. S.) coal, (Cunard, agent.)

Averages.	Remarks.
3.75 49.25 138.43 9.836 12.0625 6.1927 51.141	In a very close approach to total combustion, as well as in many other of its properties and modes of action, this sample manifests its affinity with the Pictou coal procured in New York.
1029.77 16.4735 2.7275 7.4664 7.43 8.3732	The rate of evaporation with air-plate open is 16.5 per cent. less rapid than with the plate closed.
221°.14 312°.5 .3383	With the air-plate open, as in the second trial, the gases going to the chimney had a temperature 35° higher than with the same plate closed, as in the first experiment. The considerable coating of soot on the flues may have helped to keep the gases at their high temperature, and to diminish the evaporative effect, as seen in lines 41 and 43.
156°.9 87°.33 7.4506 8.4848 417.92 9.6481 1.4398 6.4962	The second trial had the advantage of a stronger draught than the first.

GEOLOGICAL SURVEY OF CANADA.

DRUMMOND COAL ON QUEBEC STEAMERS.

portunity for making a steamer-trial of the Drummond coal during last season, but a few facts concerning the success with it is used on the Quebec and Gulf Ports Steamship Company's "Secret," "City of Quebec," and "Gaspé," may not be out here. These steamers run from Quebec to Pictou, touching at the Gaspé, and several other points on the Gulf of St. Lawrence. The following information was obtained through Mr. A. P. Pictou, agent Q. and G. P. S.S. Co., (to whom my thanks are due for interest in this matter,) by sending blank forms to the engineers of the steamer, including questions and suggestions, which forms, filled up with the requested information, were returned to me, including the questions, or adhering to the words of the original general abstract will be given of their contents.

STEAMSHIP "SECRET."

Form filled up and signed by Thomas D. Finegan, engineer

Ship "Secret" is 622 tons register. Her engines are oscillating, cylinders 50 inches diameter, 54-inch stroke. Two boilers; close return tubes. Working pressure of steam from 17 to 20 lbs. Steamer has used Drummond coal about five months (Nov., 1869.) Quantity taken on board per trip is from 105 to 137 tons, and about 10 tons are used per day. In comparison with other coals, Mr. Finegan says: "I have found in practice, 20 tons of best Welsh coal, in evaporation, are equal to 27 tons Intercolonial (Drummond) coal, and 27 tons of Intercolonial coal equal to 30 tons Scotch. All things considered, I rather have Intercolonial coal." His further statements indicate:—The opening between the grate-bars of the steamer-furnace are only 1 inch apart, no slack is wasted by falling through the grate; that the coal cakes but little on the grate; that but little ash is formed, but that what there is, is in sheets of some thickness; compared with the English and Scotch coals as used on the steamer, this coal gives "considerably more" ash. In answer to the final question: "Is there anything else you can think of, either for or against the use of Drummond coal?" Mr. Finegan states: "Intercolonial coal has given me good results, all things considered. I look upon it as good quality steam-coal, saving so large an amount of ash occasions much extra work, but more than compensated by the saving in grate-bars, which are none of expense, and they last much longer with this coal, than when many other coals are used."

STEAMSHIP "CITY OF QUEBEC."

Information received from Thomas Palaquie, engineer.

Steamship "City of Quebec" is 499 tons register. Engines oscillating, ss. "City of Quebec." with two cylinders 57 inches diameter \times 56 inches stroke. Two boilers with eight fires. Working pressure of steam, 18 lbs.

The Drummond coal has been used on this steamer since 17th May, 1869, (Nov., 1869.) The quantity taken on per trip is about 130 tons, and with eight fires and running at full speed, about 36 tons are used per day.

The coal generally burns well, not falling to pieces when thrown on a hot fire, and not caking. It forms clinker in sheets, but this clinker does not stick to the bars, and the ash, which is white, is about twice the quantity produced by English or Scotch coal.

STEAMSHIP "GASPE."

Form filled up and signed by John Campbell, engineer.

The steamship "Gaspé" is of 231 tons register. She has oscillating s.s. "Gaspé." engines (two cylinders 32 inches diameter \times 3 feet stroke), and one tubular boiler. When this information was furnished (Nov., 1869), the Drummond coal had been used but two trips on this steamer. The quantity of coal taken in per trip stands as follows:—At Quebec, 70 tons Scotch; at Pictou, from 63 to 65 tons Intercolonial (Drummond); the amount of the last burnt per day, equalling about 12 tons.

In comparison with other coals, Mr. Campbell states:—

"I find that Intercolonial coal lasts longer than Scotch; in proof of this: 4th trip from Quebec, 65 tons Scotch, 109 hours running time; 4th trip up, 58 tons "Intercolonial," 118 hours running time; 5th trip down, 62 tons Scotch, 98 hours. You will see that we ran 118 hours with 58 tons Intercolonial, against 65 tons Scotch coal in 109 hours."

Further statements indicate that no inconvenience is felt from the slack falling through the grate, when the bars are properly pitched; that the coal cakes on the grate when damp; that it forms whitish-brown clinker in sheets which does not adhere to the bars; and that it leaves a considerable quantity of yellowish-gray ash, which is "sometimes nearly black."

PICTOU COALS ON OCEAN STEAMERS.

For some months past, coals from the Acadia-West and Drummond Trials on the Allan Line of Steamships. collieries have been used on the large ocean-steamers of the Montreal Ocean Steamship Company (Allan's line), on the homeward voyages from Montreal in summer and Portland in winter, to Liverpool and Glasgow.

The regular supply of coal has, I believe, been furnished by the Acadia colliery (Acadia steam-coal), though several thousand tons of Intercolonial (Drummond) coal have also been used. Through the kindness of Messrs. H. & A. Allan, I have been allowed to examine the reports of the engineers of a number of their steamers, concerning comparative trials of these coals (as supplied at Montreal and Portland), with the Welsh steam-coals supplied for the outward voyages, at Liverpool, and have permission to include the more important results of these trials in this Report. The general result appears to be satisfactory, except in one particular, viz.:—the large amount of ash produced; but the inconvenience felt from this cause is in most cases counterbalanced by the small amount of sulphur in the coals, the absence of adherent clinker, and the consequent preservation of grate-bars.

Consumption, as compared with Welsh.—The record of comparative daily consumption of these and Welsh coals during some of the trials, is as follows:—

1. S.S. "Peruvian," (Report Jan., 1869.)
63 tons 10 cwt. Acadia = 50 tons 10 cwt. Welsh = 57 tons 10 cwt. mixture of the two coals = 124:100:115.
2. S.S. "Nestorian," (Report 1st Feb., 1869.)
68 tons Intercolonial = 55 tons Welsh = 123:100.
3. S.S. "Hibernian," (Report 9th Feb., 1869.)
62 tons Pictou (principally Intercolonial,) = 50 tons Welsh = 124:100.
4. S.S. "Nestorian," (Report 17th Feb., 1869.)
69 tons Intercolonial = 59 tons Welsh, (pressure of steam being as 18:25.) This (taking steam-pressure into consideration,) = 162:100.
5. S.S. "Hibernian," (Report 1st March, 1869.)
58½ tons mixed Acadia and Intercolonial = (estimated) 51 tons Welsh as received in Portland, or 48 tons as received in Liverpool = 121:106:100.
6. S.S. "North American," (Report has no date.) It states that 45 tons of Acadia coals are consumed per day, being same consumption as with Welsh, but pressure of steam is 4 or 5 lbs. less than with Welsh. If pressure of steam with Welsh = 25 lbs. (?), then ratio of Acadia and Welsh would = 118:100.
7. S.S. "Nestorian," (Report of 28th March, 1870.)
66 tons Acadia = 59 tons Welsh coal, steam-pressure being 22½:25 lbs. This indicates the ratio of 122:1.00, taking steam-pressures into consideration.

AVERAGE RATIOS OF DAILY CONSUMPTIONS, FROM ABOVE TRIALS.

1. Welsh* to Acadia	100.0 : 121.3	Comparison Pictou and Welsh coals.
2. " " Intercolonial, including trial No. 4.†	100.0 : 136.3	
3. " " Intercolonial, rejecting trial No. 4	100.0 : 123.5	
4. " " mixture, Welsh and Acadia	100.0 : 115.0	
5. " " Acadia and Intercolonial	100.0 : 121.0	
6. " " Welsh as delivered in Portland	100.0 : 106.0	

Ashes and Clinker.—Mr. Flett, chief engineer of the S.S. *Peruvian*, in his Report of June, 1869, says:—"There is a large quantity of ashes from the Acadia coals, but little clinker, which enables us to clean the fires easily, as nothing sticks to the bars." Mr. Dick, chief engineer of the S.S. *Hibernian*, says:—"The fires are easily cleaned, that is, the clinkers do not stick to the bars, neither do they burn the bars." The other engineers complain of more or less clinker from both Acadia and Intercolonial coal; the Acadia, however, appears to give the least trouble in this respect. This is owing to the fact that the Intercolonial coal is the softest, and if not properly stoked would be inclined to clinker. The fact that some engineers burn these coals without clinker, is sufficient proof that it is possible to do so in every case. As I shall presently show, it is probable that, if these coals are burnt with a fire, thin at the bridge, deep at the fire-door, with proper perforations in the door, (equalling at least 8 or 10 square inches per square foot of door,) there should be no difficulty in keeping good steam, and avoiding the large flat clinkers which are complained of; but attempts to burn these caking coals on a thin flat fire such as is generally made in burning Welsh steam-coals, which are not inclined to cake, will never result in success.

The amount of refuse from these coals in proportion to Welsh, is variously estimated by the different engineers; the average seems to be, in buckets thrown overboard per watch of four hours:—Welsh, from 15 to 18; Pictou, from 35 to 45.

Smoke, etc.—The only mentions made of smoke in these reports occur in the reports of Messrs. Jack, of the *Hibernian*, and McMaster, of the *Nestorian*, both of whom complain that when urging the fires to get all the steam possible, large volumes of smoke and flame are seen coming from the funnel. I need hardly say that this manifestly results from an improper arrangement of the draught, and it would appear from this that no air is supplied above the fire, to assist in burning the volatile matters passing off from the coal in coking, previous to combustion. This must result in a great loss of coal, and can be partially remedied by the same change in

* Welsh, "best Welsh steam-coal, delivered in Liverpool."

† The low result of trial No. 4 is probably due to bad management of the coal. It is so discordant with other results that I think it should be rejected.

management mentioned above, viz.:—proper stoking, and perforated doors. This subject will be further considered under the next heading, paragraph *Smoke consumption.*”

GENERAL REMARKS ON STEAM-TRIALS.

The general result of all the trials above described has been to demonstrate the fitness of the coals used, for steam production, whether under stationary marine or locomotive boilers. As the result of each separate trial can be compared with similar trials of foreign coals, by reference to any work on standard coals or engineering practice, it seems unnecessary to make any such comparison here.

A few remarks on late experiments on the consumption of such coals, however, may not be out of place, but though of very great importance to the coal trade, a full discussion of the subject will not be practicable, without extending this Report far beyond the limits to which it must necessarily be confined. A prejudice existed for a long period against using bituminous coals as steam-producers, especially in the Navy, on account of the large amount of smoke produced in burning them, and their low evaporative power, as compared with anthracites, or the so-called free-burning coals of the Welsh coal-fields. The heavy black smoke emitted from the funnel of a steamer burning these coals rendered them quite unfit for the use of ships of war, and in towns and cities became a serious nuisance. Their evaporative powers, as has already been stated, were supposed to be dependent on their content of fixed carbon, which supposition seemed to be quite justified by practical experiments. The most successful trials with the old style of furnaces failed to give them the value of the Welsh steam-coals, in proof of which I may cite the final results of the British experiments (De la Beche and Playfair's), in evaporative powers:—

Average of	37	samples from Wales.....	9.05	lbs.
"	17	" " Newcastle.....	8.37	"
"	28	" " Lancashire.....	7.94	"
"	8	" " Scotland.....	7.70	"
"	8	" " Derbyshire	7.58	"

Of the above list of coals, the coals of the Pictou district approach nearer the Newcastle Hartley, or North Country coals than to any other class known, and it will be, therefore, of the greatest interest to show the change of opinion which has taken place with regard to these coals within the last few years; to mark how all the old prejudices have disappeared, and to ascertain with what success these coals are now consumed as steam-producers.

To accomplish this object in the most direct manner, I cannot do better

than quote from the "Report of a Committee appointed by the North of England Institute of Mining Engineers, to investigate the smoke question" (dated Oct. 24th., 1860.) After mentioning the causes that led to the appointment of this committee, they state :—

Smoke consumption.

"They (the Committee) cannot, however, forbear remarking that there is really very little left for them to do. A few years ago, in 1855, there was an impression that North Country steam-coal not only made smoke when burnt, but was of an inferior evaporative power to that of the so-called smokeless Welsh coal. Since then, on two subsequent occasions, this has been proved, most satisfactorily, to be an error. In 1856-7, experiments were made at Elswick, conducted by Sir William Armstrong, Mr. J. A. Longridge and Dr. Richardson, which fully demonstrated that Hartley could give, without smoke, 12.9 lbs., and Welsh 12.35 lbs. of water evaporated from 212°, per pound of coal, in an ordinary marine boiler; and in 1864, Mr. Miller, at the request of the House of Commons, made a series of experiments which proved again most satisfactorily that Hartley could give without smoke 10.68 lbs., and Welsh 10.13 lbs. of water evaporated from 100 per pound of coal. Again, at Wigan, in 1867, Messrs. Fletcher and Dr. Richardson conducted a series of experiments proving most conclusively that a bituminous coal, more difficult even to manipulate in the fire than the coal of this district, can be economically and *smokelessly* consumed. All these results have been accomplished with the smallest possible alteration of the furnace and bars of ordinary marine boilers. Your Committee, therefore, have, from many and various sources, the highest authority for stating that, as far as experiments can do so, the question is practically *solved*, and more particularly in connection with any ordinary quality of round coal, and in Cornish or marine boilers of ordinary construction. It could hardly be expected that any further experiments would produce better or more conclusive results, or be attested by gentlemen of higher reputation and position.

Lake experiments.

* * * * *

"Believing, as they do, that the semi-bituminous steam-coal of this district can be burnt without smoke, so as to give as high, if not a higher and more speedy evaporative power, than Welsh (as might be expected from its chemical composition), your Committee can by no means aver that this most important fact is comprehended by the great bulk of consumers; but they are not of opinion that any further experiments in this direction are necessary, as it seems to them that data on this subject are so numerous already, that the public may be properly left to draw their own inferences thereon.

"If your Committee were asked for the reason for so much incredulity on a subject so important to the interests of the Northern coal-owners, they

would suggest that it, to a certain extent, arises from the fact that the steamships built in the neighbouring ports are not, as a rule, by any means successful either in their attempts to prevent smoke, or to obtain the highest results from the coal of the district. These steamers, going from port to port, and from country to country, assist in advocating the views of those who refuse to recognise the value of the Northern steam coals, and your Committee regret that the boilers of these ships at least are not constructed so as to bear out the results so laboriously obtained at such great cost.”*

Many of the statements in the above extract will apply with almost equal force to our own coals. It is scarcely possible that we shall obtain the very high results in evaporative power above indicated, from the Picton coals, from the fact that the amount of ash in these coals almost invariably exceeds that in the coals of the North of England; but it is certain that with proper furnaces, the evaporative power of our coals may be materially increased, probably to the extent of from twenty-five to thirty per cent., and there seems no reason to doubt, that, in the matter of smoke, our coals may be as successfully burnt as those of the North Country.

Mr. Banning's
experiments.

In this connection it will be interesting to examine into the success with which the Newcastle coals are burnt without smoke, and to this end, an abstract of the experiments of Mr. T. W. Bunning, of Newcastle-on-Tyne, on the steamer “*Weardale*,” will most conclusively show the wonderful improvements made from the results of the old system of burning the coals, by a very slight change in the furnaces and bars. A series of smoke-trials were made on this steamer with the ordinary furnace, fitted with grate-bars five feet long, and the exact amount of smoke produced by Hartley coal was obtained by a method presently to be described. An alteration was then made in the furnaces, which consisted simply in shortening the bars to three feet six inches, and introducing an *air-plate* (of fire-bricks with open spaces between them, hung on iron bars), at the back of the fire. Underneath this air-plate was a flue, or open space, separated from the ash-pit of the furnace by a cast-iron plate, carrying the brick forming the bridge proper of the furnace. This cast-iron plate was pierced with a hole giving communication between the ash-pit and air-plate flue, when open, and thus admitting air between the fire and the chimney, through the spaces between the fire-brick forming the air-plate; or this hole could be closed by a shovel-full of ashes and cinder. Beside these simple alterations the furnace-doors were fitted with perforated flash-plates, through which the air was allowed to pass into the furnace, in front of the fire, but above the grate. After the alteration, another series of experiments was tried with the steamer, and with the most signal success. The results were published in the Transactions of the North of England Institute of Mining Engineers, and accom-

* Transactions North of England Institute of Mining Engineers, vol. xviii, pp. 37-38.

pany a short paper by Mr. Bunning, a portion of which will subsequently be quoted. As it will be impossible to reprint in full, the tabulated results of these trials, it will be necessary to explain the method adopted (and now, I believe, agreed to as the standard by the Imperial Government), for estimating the exact amount of smoke produced by a given coal, consumed in the furnaces of any particular steamer. It is this:—Let the smoke issuing from the funnel of a steamer be noted every minute for an hour, upon a blank table, subdivided into minute-columns, similar to the table published with the Acadia coal-trial on the steamer “St. Lawrence” (Trial No. 2, of this Report). Let the figure 1, placed in a minute-space, indicate that the very faintest possible smoke, a mere indication of light-coloured gas was visible; 2, that this was increased, and so on to 6, indicating the densest black smoke. Having obtained these *smoke-marks* for an hour, the addition of them gives the *smoke-equivalent* for that time. This understood, the extract from Mr. Bunning’s paper above referred to, will become intelligible to the reader. After referring to the tabulated record showing the smoke-marks for every minute during his experiments, he states:—

Rule for estimating smoke.

“It will be seen that before the alteration, this smoke-equivalent averaged 107.9 over 25 experiments; that frequently, and for several consecutive minutes, dense black smoke was issuing from the chimney, and that there was rarely any actual cessation from smoke; while after the alteration no smoke of greater intensity than 2, was ever visible, and this only nine times in eighteen hours, for a minute each time; and that during the same eighteen hours the average smoke-equivalent was 7.7, each mark so rarely exceeded 1. This indicates that the very faintest possible smoke was visible only for 7.7 minutes in each hour, no smoke whatever being visible for the other 52.3 minutes. It would be vain to look for, nor indeed can any better results be found, even when the best of the so-called smokeless coals are burnt; for all practical purposes, therefore, good Hartley coal, as consumed in the *Weardale*, may be considered as smokeless as any other known coal. The plate* shows the alteration made to the fire-bars and bridge; the former were reduced from 5 feet to 3 feet 6 inches. The doors were not changed, and those shewn are those used by the Admiralty, admitting air at the bottom.†

Experiments on the Str. “Weardale.”

“The secret of burning the North Country steam-coal, and in fact all other good steam-coal, is to put it on as large as possible, as thick as possible, and to have as great a draft as possible, so as to burn off as large an amount per square foot of grate-surface as possible.”‡

Rule for burning North Country steam-coal.

* Published with Mr. Bunning’s paper.

† That is, the bottom of the door; the air passing into the fire through a perforated flash-plate.

‡ “On Experiments on the *Weardale*.” Trans. N.E. Inst. Mining Engineers, vol. xviii., pp. 105 et seq.

Farther trials
and alterations.

Since these trials, which were carried out in the winter of 1868-9, farther experiments have been made by Mr. Bunning on the Weardale, and some slight alterations made, among which may be mentioned the placing of a door at the hole piercing the plate between the ash-pan and air-plate flue, which being moved by a bar extending to the front of the furnace, permits the admission of air, *at will*, behind the fire. Under date of 14th April, 1870, Mr. Bunning (to whom I am indebted for much information on this subject, which I would here gratefully acknowledge, writes me :—

Success.

“We consider the Weardale, now perfect; she makes absolutely no smoke, and keeps her steam well.”

A proper discussion of the rationale of these experiments, and of their importance to our coal-trade, must be postponed to some future occasion. Much more might be said in favour of the use of steam-coals of the class under consideration, and it can be clearly proved, that, if properly burnt, they are at least as economical, as smokeless, and as easily stoked as any other class of coals.

Use of New-
castle coal in
the Navy.

The experiments above quoted, in connection with Government trials made at Devonport, already mentioned, have produced a material change of opinion with regard to Newcastle coal, and it has now taken a position second to none, among coals for the Navy, where it is chiefly used in admixture with Welsh coal, and the testimony of the very highest authority, is that a very large saving has already been effected by its use.

Necessity for
steam and
smoke-trials
of our coals.

It is hoped that enough has already been said to call the attention of our coal-owners and consumers to the urgent necessity of practical trials of a similar character to those above mentioned. Such experiments could be carried out at a very trifling cost, on any steamers, without interfering with their regular voyages; and though the great results of the North Country experiments might not be obtained, still, a great addition would be made to our knowledge of the coals, and that a very material improvement in the matter of steam and smoke would be made, cannot be doubted.

I shall close these remarks, which have already exceeded the length originally assigned to them, by an extract from a circular of the Coal Trade Association of Newcastle-on-Tyne, just received from Mr. Bunning. It is of interest as showing the results of the very latest trials.

RESULT OF EXPERIMENTS AT PORTSMOUTH, 1869-70.

Experiments at
Portsmouth
1869-70.

“A very comprehensive series of experimental trials have been carried out during the past twelve months on board Her Majesty’s steamers “Urgent” and “Lucifer,” at Portsmouth, with Welsh and North-

Country coal mixed, and burnt in two forms of furnace, for the purpose of ascertaining the best proportions in mixed coal, and form of furnace for the consumption of smoke. The trials have been carried out under the direction of Captain E. Rice, A.D.C. to the Queen, commanding the Steam Reserve at Portsmouth, and the superintendence of Mr. G. Murdock, Chief Inspector of Machinery to the Reserve; and the results are considered to be so important, that orders have been issued from the Admiralty for the furnaces in the boiler-rooms of her Majesty's ships to be altered according to the plan finally adopted in the trials as the best for the consumption of smoke. When the comparative trials between the ordinary and the new form of furnace commenced, the proportions of the mixed coal burnt were one-third North-Country and two-thirds Welsh; but in all the later trials the coals have been burnt in equal proportions, and under these latter conditions less smoke has been emitted from the smoke-consuming furnace funnel than has been emitted from the funnel over the ordinary form of furnace, when the latter was burning the very best description of Welsh coal. The last three trials made on board the "Urgent" afford conclusive evidence of the success of the new form of furnace over the old. In the trial made on the 27th ult., both sets of furnaces were used, the coal burnt being Ferndale and Cowpen's Hartley, in equal proportions. The report of this trial gave the following results:—

Change of furnaces in the navy.

H. M. S. "Urgent."

	New Furnace.	Old Furnace.
Smoke.....	1.55	4.55
Coal burnt per hour.....	2,940 lbs.	3,294 lbs.
Producing		
Ash.....	23.14	32.75
Soot.....	2.82	5.16
Clinker.....	35.08	25.00

"The last two trials made were on the 2nd and 11th insts., the new furnaces only being used on the former, and the old furnaces only on the latter trial, the coal burnt in each instance being equal quantities of Powell's Duffryn and Cowpen Hartley, with the following results:—

	New Furnace.	Old Furnace.
Coal burnt per hour.....	2,912	3,397.3
Producing		
Ash.....	17.73	24.34
Soot.....	1.94	4.06
Clinker.....	31.0	40.6

"In these two trials, the new furnaces exhibited a saving upon the old, of 14.28 per cent. in fuel, an increase of 7.56 per cent. in horse-power, and a positive gain in the consumption of smoke, of 21.84 per cent."

PRACTICAL TRIALS IN GAS MAKING.

Requisites of a
gas-coal.

The most important requisites of a gas coal are :—1st. That it contains a large amount of volatile combustible matter (gas);—2d. That this volatile matter be of good illuminating power, and as free as possible from sulphur, and—3d. That the coke furnished by the carbonization of the coal be bulky, and at the same time firm, (*i. e.* not inclined to be granular.)

The importance of the first requisite, will be evident to all. The percentage of volatile matter in true coals usually employed in gas-making, is from 25 to 40 per cent., and in cannels it rises to 60 or 70 per cent.

Gas-content.

The true bituminous coals of this district which are now being worked, average, according to the latest analyses, as given in the first Section of this Report, about 28 or 29 per cent. of volatile matter; the content of the hardest being 20.46 per cent., and of the softest being 38.84 per cent. The oil coals, oil shales, and a single cannel range higher in gas-content, the stellarite reaching 68.38 per cent., and Lawson's cannel 41.18 per cent., which last figure is not, however, a high percentage of volatile matter for a cannel. That the percentage of volatile matter, given by analysis in the small way, is not always a true index of the value of a gas-coal, will be seen by a reference to the analyses of the Foord-pit coal, which stands nearly at the head of the list of Pictou (true) coals, as a gas-producer. The percentage of volatile matter appears rather low in this case, in fact so much below what would be expected from so good a gas-coal, that I am inclined to suspect that the samples analysed in the small way, were not fair averages of the produce of this colliery.

Quality of gas.

That the gas produced from the coal be of good illuminating power, is most important, will also be seen, though from the fact that the standard of illuminating power can easily be raised by the addition of a few per cent. of some rich cannel, or substance of the character of the stellarite, many coals, which produce gas of a low standard, but in large quantity, (if they coke well,) are often used as gas-coals. The stellarite has been used to raise the standard of illuminating power of gas from other coals; as are also, torbanite, albertite, cannels, and many oil shales. To instance a case of this kind, I may state that Mr. Thompson, of the Pictou Gas-works informs me that when using a coal giving *per se* 15-candle gas, he adds 10 per cent. of Leshmahagow cannel, in order to raise the gas to the standard of 18 candles.*

* The standard candle in testing gases, is of spermaceti, burning at the rate of 120 grains to the hour. To compare the illuminating powers of gases, the light given by a standard burner burning five (5) cubic feet per hour of the gas under examination, is compared with the light of one of these standard candles, the result giving the candle-

The majority of the coals of the Pictou region furnish an excellent coke. in the gas-retorts, if properly carbonised, as will be abundantly proven by the statements to be given below from some of the first gas-chemists of this continent. Statements have recently been published to the effect that coke from these coals is worthless. In a single case this may be warranted; in the majority of cases it is not, as from a number of the coals I have seen most excellent coke made in the gas-retorts of the Pictou works. It is true that if the heat is not properly applied, the coke cannot be properly formed, and a few of these coals will never be successfully coked, but the testimony of our first gas-chemists, such as Buist of Halifax, and the engineer of the Boston Gas works, who have used many thousand tons of the coals, is that some of them furnish good merchantable coke.

The greater number of the coals of this district will, I believe, compare favourably with those of any district of the world in regard to sulphur. A number of analyses in the first section show the sulphur-content of the different coals, which in most cases is considerably below 1.00 per cent. These determinations of sulphur may be compared with the following table, giving averages of determinations of sulphur in a large number of the coals of Great Britain, from the analyses given in the reports of the British Admiralty Trials:—

				Per cent.
Average of 37 samples from Wales. gave of sulphur....				1.42
"	17	"	Newcastle,	.... .94
"	28	"	Lancashire,	.... 1.42
"	8	"	Scotland,	.... 1.45
"	8	"	Derbyshire.	.... 1.01

Further statements concerning the small amount of sulphur in Pictou coals, will be found in the extracts of letters from Messrs. Buist and Greenough, given below.

GAS TRIALS AT THE PICTOU GAS-WORKS.

Mr. Alex. Thompson, of the Pictou Gas-works, has used all the coals which have been worked to any considerable extent in this region, and he has been kind enough to supply me with notes of his experience, from which the following tabulation has been compiled.

power of the gas. Thus if we suppose a gas burnt in a five-foot burner to give fifteen (15) times the amount of light furnished by one standard candle, the gas is said to have 15-candle power or to be 15-candle gas. The standard of gas in our large cities ranges from 13 to 18-candle power.

Gas trials at
Pictou.

PRODUCTION OF GAS, AND QUALITY OF GAS AND COKE, FROM VARIOUS COALS AT THE PICTOU GAS-WORKS.

(FROM NOTES OF MR. ALEX. THOMPSON, MANAGER.)

Company shipped by, and name of mine.		Cubic feet of gas (per ton of 2240 lbs.)	Illuminating power (candles.)	Busbels of coke per ton.	Character of coke.	Remarks.
Results of trials at Pictou.	GENERAL MINING ASSOCIATION.					
	Foord Pits, (1869 shipments.)	8,000	18	35	Good.	
	Albion (Old) Mines.....	7,700	16	34	"	
	Forster Pit.....	6,000	13	32	Not good.	Coke unsaleable.
	Dalhousie Pit.....	7,500	15	32	Good.	
	Cage Pit, (old shipments)....	7,800	17	34	Good.	
	ACADIA COAL COMPANY.					
	McGregor workings.....	7,600	14	34	Fair.	Coke firm, but sulphurous.
	Fraser Mine, stellar coal....	11,000	35	.....	.....	Coke worthless.
	" oil-shale.....	8,000	30	.....	.....	"
	Acadia Colliery, west slope.	7,000	13	32	Not good.	Coke granular.
	INTERCOLONIAL COAL COMPANY.					
	Drummond Colliery.....	7,700	15	34	Good.	
	NOVA SCOTIA COAL COMPANY.					
	Nova Scotia slope.....	7,000	14	32	Fair.	Coke saleable.
	MONTREAL AND PICTOU COAL CO.					
	Montreal and Pictou pit....	6,000	12½	28	Not good.	
	PICTOU COAL MINING COMPANY.					
	Marsh Colliery.....	6,000	14	28	"	

Of the coals named in the above list, that from the Foord pits appears to give the best result in gas-making, from its large gas-content, the high illuminating power of the gas, and the superior coke produced in its carbonization.

Value of the different coals.

The Drummond coal, and the coals of the Old mines, Dalhousie and Cage pits, appear to stand next, the value of the other coals for gas purposes falling slightly below these. The stellarite and oil-shale of the Acadia mines are most valuable for mixing with the coals, to increase their illuminating power, but would not be of great value if used alone, for two reasons: because their cokes are worthless, (being merely a cinder, with but a few per cent. of fixed carbon, and therefore useless in heating the retorts); and because the gases produced in carbonizing them are too carbonaceous for use with ordinary burners. Good coke is not only valuable to the gas-manufacturer as a merchantable product, but also is used for heating the retorts, and therefore cannels, and substances like torbanite, stellarite, and albertite, though producing a large amount of highly carbonated gas, are seldom used in gas-manufacture, except in mixture with coals furnishing a good coke.

I shall now proceed to give such facts as it has been possible to procure concerning the value of the different coals of this district in gas-manufac-

ture, some of which facts have already been published, while others have been obtained by correspondence, and in one case a special trial has been made at the Pictou Gas-Works.

COALS OF THE ALBION MINES.

The following extracts are from letters by Mr. George Buist, Manager and Chemist of the Halifax Gas Company, and Mr. W. W. Greenough, Manager of the Boston (Mass.) Gas Company, in answer to letters from myself, soliciting information for this Report. The companies represented by these gentlemen, have been for years large consumers of the Albion Mines coal.

LETTER OF MR. GEORGE BUIST.

(Copy.)

GAS OFFICE, HALIFAX, N.S., Feb. 24th, 1870.

Edward Hartley, Esq.,

DEAR SIR,—

I beg to acknowledge receipt of yours of 8th instant, making enquiries regarding Pictou coal.

I think the following statement may be taken as giving the correct quantities of the gas, coke and tar produced from one (1) ton of 2,240 lbs. Mr. Buist's letter.

The quantity of gas will average about.....	7,300 cubic feet.
Illuminating power, about	15½ to 16 candles.
Weight of coke, about.....	1,450 lbs.
Quantity of coal-tar, about.....	9½ to 10 gallons.

The sulphur in the Pictou coal is very much less than in any of the other Nova Scotia coals. The quality of the coke is very good indeed. * * * *

I remain,

Yours truly,

(Signed,)

GEORGE BUIST.

LETTER OF MR. W. W. GREENOUGH.

(Copy.)

OFFICE OF BOSTON GAS LIGHT COMPANY,

No. 20 West Street, Boston, Feb. 7th, 1870.

Edward Hartley, Esq.,

DEAR SIR,—

Your letter of inquiry of the 4th instant reached me * * * * *

We use the caking coals of Pictou and Cape Breton, in combination with richer coals. The proportions of these combinations are based upon experimental trials of each coal separately. Mr. Greenough's letter.

The best results in gas-making with the Pictou coals, are obtained by working the retorts at a cherry-red heat. One then gets from each ton of 2240 lbs., 7280 feet of gas—of strong 15-candle illuminating power, with a yield of 1325 lbs. of coke of fair quality. Higher heats will give more gas of an inferior grade, and with a diminished value of coke. This coal contains but a small proportion of sulphur compounds, is easily purified, and may be safely stored without danger from spontaneous combustion. *

Yours truly,

(Signed,)

W. W. GREENOUGH.

* The rest of this letter refers to Cape Breton coals, and need not be quoted here.

I would take this opportunity to thank Messrs. Buist and Greenough for the above facts, and for other valuable information they have kindly given me.

The statements in the following memorandum, sent me by Mr. Jas. Hudson, Chief Manager of the General Mining Association, are partially a repetition of the above facts:—

“Extract from letter of W. W. Greenough, Esq., Treasurer of Boston Gas Light Company, December, 1869.

“‘We have made no recent analysis of gas made from Pictou coal, but the experience of several years working shews a uniform result:—with cherry-red heats, of $3\frac{1}{2}$ cubic feet to the pound, of 15-candle gas; with a condensation by bromine of 6.75; a specific gravity of 4.75; and the *smallest per centage of sulphuretted compounds of any coal called caking*. Coke fair. Higher heats will give more gas, at the expense of the illuminating power of the gas, and the quality of the coke.’”

MCGREGOR COAL (ACADIA MINES).

McGregor coal. The following statements are from the published report of Mr. Jesse Hoyt, Manager of the Acadia Coal Company, 1866:—

“On the 9th. of February, 1865, one ton of this coal, a mixture of both benches, was tested in the works of the Manhattan Gas Company, New York, with the following results:—

trial at New
York, U. S.

“‘One ton of 2,240 lbs. yielded 9,500 feet of 13.03-candle gas, and 41 bushels of coke, weighing 1,640 lbs. The coke is good; it contains rather much ash, and makes some clinker, but it burns well, keeping up a good strong fire. The coal seems to deserve a trial on a larger scale, as it is very readily carbonized, yielding a good volume of gas and coke.’”

Analysis of the coal.

Volatile matter.....	32.0
Fixed carbon.....	59.3
Ash	8.7
	<hr/>
	100.0

“A subsequent trial was made by the same company, but the result was not so favourable, as will appear by the following report:—

Second trial.

“‘One ton of 2,240 lbs. yielded 9,500 feet of 13.34-candle gas, and 38 bushels of coke, weighing 1,744 lbs. The coke is poor; it clinkers badly, and does not keep up the fire under the retorts. It requires 4 bushels of lime to purify a ton.’”

Analysis of the coal.

Volatile matter.....	26.8
Fixed carbon.....	57.9
Ash.....	15.3
	<hr/>
	100.0

Mr. Hoyt remarks that he believes the unfavourable result in the latter trial, to have been caused wholly by the admixture with the coal, of foreign matter from the *shale-band* or fire-clay parting, between the first and second benches of the McGregor seam.*

DRUMMOND COAL.

Through the kindness of Mr. Dunn, Manager of the Intercolonial Coal Company, I procured a special gas-trial of three coals, from the three upper divisions of the Acadia seam, as worked at the Drummond colliery. Drummond coal.

This trial was made under the superintendence of Mr. Alexander Thompson, Engineer and Manager of the Pictou Gas Company, at their works. The samples were of two barrels each, and believed to be fair averages of the different benches. They were marked and numbered as follows :— Special gas-trials.

Sample No. 1,—Top of seam, (2 feet 6 inches thick) left in the workings.

" No. 2,—From the fireclay *holing*, 2 feet up to the smooth parting. (Fall coal.)

" No. 3,—First bench. Below the *holing*, and 4 feet thick.

The numbers of these samples correspond to the numbers of the divisions and analyses of this seam at the Drummond colliery, in Section I. of this Report.

The following is a copy of Mr. Thompson's Report :—

(Copy.)

GAS WORKS, PICTOU, N.S.
December 4th, 1869.

Mr. Thompson's
Report.

Edward Hartley, Esq.,
Geological Survey,

Sir,—

At your request I have carefully examined the contents of six (6) barrels of coal from the Drummond colliery, marked respectively Nos. 1, 2, and 3, with the following results :—

No. 1,—Yields at the rate of 7,000 cubic feet of gas and 32 bushels of coke to the ton.

No. 2,— " " " 7,500 " " " 32 " " "

No. 3,— " " " 8,500 " " " 36 " " "

The gas has an illuminating power of 15 candles. The volatile combustible matter is such in amount and character as to promise well in gas-making. The coke is firm and of good quality, well adapted for heating the retorts in gas-making, and can thus take the place of coal for that purpose.

I am, Sir,

Your obedient servant,

(Signed,)

ALEX. THOMPSON,
Engineer and Manager.

Beside their use as steam and gas-producers, several Pictou coals are sold extensively for various other purposes, among which may be mentioned, re-heating iron, blacksmithing and domestic purposes. The cokes of one

* See Geological Report, Section 4, pp. 67-et seq., beds 71—73, See also page 96 of the same Report, and the first Section of this Report.

or two of the coals have also been, to a certain extent, successfully used in iron-smelting and founding. I am not at present able to furnish any exact data concerning the success with which they are used in rolling-mills etc., and no iron-smelting is at present carried on at any point near the Pictou district; but I am aware that in the Eastern United States, the coals are used in various forges and rolling, mills, with very good success, and I am assured by Mr. E. A. Jones, Manager of the Acadian Iron Works at Londonderry, Nova Scotia, that he has used Albion Mines coke in iron-smelting, and finds it better suited to this work than any other Provincial coal he has used.

For domestic purposes these coals are well and favourably known; they light easily in the grate and burn well and long with very little attention, except in the few cases where the content of ash is very large.

III.

IRON ORES OF PICTOU COUNTY.

Localities of iron ore.

A number of localities are known in the vicinity of the Pictou coal-field, where ores of iron have been found. None of these have ever been developed to any extent; and the few trial-pits upon the deposits, afford very unsatisfactory evidence as to their size and value. The ores of iron which have been recognized in this vicinity are; specular iron, limonite or brown hematite, and spathose ores (crystalline carbonates of iron); besides the clay-ironstone, or argillaceous carbonate of iron of the coal measures.

In the following paragraphs, mention is made of those localities only which I have personally examined, though a large number of others exist, of greater or less value. My field-work in this district was confined to the productive coal-field, except in the few cases where examinations beyond its boundaries were made at special request. The samples analysed, where no statements to the contrary are made, were taken by myself from the deposits, and are believed to be the averages of the ores. The analyses have been made in the laboratory of this Survey, by Mr. Broome.

SPECULAR IRON.

Specular iron

Several deposits of specular iron were examined; these all occurred in a range of metamorphic rocks lying ten or twelve miles to the south of the coal field. The ore of the variety known as micaceous iron ore, was noted at Battery Hill, near Glengarry station, and proceeding east from this point at a number of localities near the line of the Provincial Railway, the range of rocks including it finally crossing this railway and the East River of Pictou, several miles above Springville. Of the age of this for-

mation, I cannot speak with certainty, but it is probably Upper Silurian ; the rocks consist of quartzites, of light and dark green, purplish, brown and black colours, and slates highly altered, generally of a black colour and giving a white streak. The quartzites are sometimes coarsely granular, but as a rule, compact and fine grained. This formation appears quite distinct in lithological character from the series which has been described in the Reports of Sir William E. Logan and myself, as occurring near the Pictou coal field, at McLellan's and McGregor's Mountains, and at Waters' Hill, and which are believed by Dr. Dawson to be of Devonian age.

Age of including rocks.

I have made no attempt to obtain fossils in these rocks, nor has any bed been observed likely to contain them, at the few localities examined ; but it seems probable that the fossiliferous beds mentioned by Dr. Dawson in his Acadian Geology, (pages 568-570), as occurring near Springville, are included in this series. These beds, from which a large number of fossils have been collected by Mr. D. Frazer of Springville, are of undoubted Upper Silurian age.

Fossiliferous beds.

The specular iron appears to exist in true fissure-veins, but of no considerable size, at any locality which I have seen. In many cases the rocks holding it appear to be much shattered, and the specular iron, with a compact granular quartz as a veinstone, appears to fill the fissures, which are often confined to a particular bed of rock, and sometimes so numerous that the entire bed contains a large per centage of the ore, and may be considered as a single deposit. The most important deposit of this class which I have observed, occurs on the west side of the East Branch of the East River about three and a-half miles above Springville, on the lots of John McDonald and Archibald Thompson. Here the specular iron seems to exist over a considerable area, some portions being quite pure, but as the deposit is opened by two shallow pits only, it is impossible to state its size, or exact relations to the including rocks. The minor veins are often of several inches in thickness, and are included in a light greenish-drab granular quartzite, which they traverse in the most irregular manner. A sample of this ore was taken by me, which appeared to represent an average of what might be mined, provided all the larger lumps of quartzite taken out in mining were rejected. This sample gave on analysis:—

Character of the deposits.

Sesquioxide of iron.....	65.14	Analysis.
Silica	32.50	
Hygroscopic moisture.....	.91	
	98.50	
Total amount of metallic iron..... per cent.	45.60	
Specific gravity	4.607	

From the amount of silica present this ore would require a considerable amount of limestone as a flux, or it could be advantageously smelted

*Gozzans from
these deposits.*

with a calcareous sparry iron ore like that used for mixture with hematites at the Acadian Iron Works at Londonderry. The locality is well worth a careful exploration, as the deposit seems continuous, and of a considerable width. It is, in common with many other of these deposits, easily traced upon the ground, from the bright rust colour of the soil, and the presence on the surface of a large amount of partially decomposed ore, or *gozzan*, which is easily recognised. The appearance of this substance is very deceptive to the inexperienced eye, and I have frequently had specimens of it brought to me, by parties who, from its uniform rust-red appearance, had been led to imagine it a very rich iron ore. Attention to its low specific gravity will often show how small an amount of iron it contains. The following is the result of a partial analysis of a sample of one of the best of these *gozzans* which I have seen. It was sent me from Rockland fulling-mills, on Middle River, by Mr. Robert Frazer, and in appearance was quite equal to some of the pure ochrey *gozzans* which are found in some other localities, but analysis shows it to be merely a porous mass of granular quartzite, deeply stained with iron-oxyd.

*Analysis of a
gozzan.*

Sesquioxide of iron.....	25.48
Silica.....	62.61
Hygroscopic moisture.....	.81
Volatile at a red heat.....	4.43
	<hr/>
	93.33
Amount of metallic iron.....	per cent. 17.84

The remaining constituents were lime, magnesia and manganese, which were not determined.

LIMONITE OR BROWN HEMATITE.

Limonite.

Numerous boulders of a very pure variety of limonite, have been found in the vicinity of Springville, on the East River, but so far as I can learn, the ore had not been found in place until Oct. 15th, 1868, when a bed was discovered, on James Frazer's land, about $1\frac{1}{2}$ miles above Springville, (on the east side of the East Branch of the East River), by Mr. A. P. Ross, of Pictou, and myself, while visiting the locality. The only exploration we were enabled to make, was a shallow pit, sunk in a few-hours by one man, but this was sufficient to expose a mass eight feet in thickness, of a pure limonite of the mammillary, stalactitic, and fibrous varieties. It was overlaid by a close grained altered sandstone or granular quartzite of a light greenish-gray colour, and appeared to be conformable to the stratification. The bottom of the bed was not exposed; it was hidden by a high drift bank; neither was the deposit traced for any

distance on the strike. Should it prove to be a persistent bed, it would be a most valuable deposit, as the ore is one of the purest known. No substance save the pure mineral was discovered in the bed, the roof appearing well defined.

The following analysis is of an average specimen taken by myself. It will be observed that the silicious residue does not equal half of one per cent :—

Sesquioxide of iron.....	84.94	Analysis.
Combined water.....	15.43	
Hygroscopic moisture .....	.92	
Silica, (insoluble residue).....	.41	
	<hr/>	
	101.70	
Amount of metallic iron.....	per cent. 59.46	

The rocks including this deposit appeared to belong to the same series as those further south, holding the specular iron deposits above described.

SPATHOSE ORES.

On the land of Neil McLaurin, about one and three-quarter miles south-west of Sutherland's bridge on Sutherland's river, a peculiar deposit of iron ore occurs, included in Indian-red and greenish-drab sandstones, apparently of the Millstone-Grit series. This ore, which I designate as spathose iron ore, appears to be a mixture of spathic iron, or crystalline carbonate of iron, and red hæmatite, or anhydrous peroxyd of iron, with but little impurity. The ore is seen in place, on the south bank of Sutherland's brook, where it is exposed by a number of costeening-pits, and it has also been traced for about 100 feet west of the point where it was first opened, the strike appearing to be very nearly E. and W., and the attitude nearly vertical.

Spathose ore
near Merigom-
ish.

Whether this deposit should be considered a bed or a vein, is still a matter of uncertainty, but it appears to be conformable with the stratification. Its thickness, where exposed, varies from eleven to fourteen feet. Several attempts had been made to trace it farther westward at the time of my visit, but the pits sunk had failed to penetrate the drift. That this deposit, if found to be persistent, would be of considerable value, may be judged from the following analyses. No. 1 is of a specimen from the outcrop, on Sutherland's Brook, and No. 2, from a costeening pit, about 75 feet farther westward.

Size of deposit.

	I.	II.
Sesquioxide of iron.....	16.98	20.52
Carbonate of iron.....	65.61	57.40
Carbonate of manganese.....	7.98	8.29
Carbonate of lime.....	2.67	4.02
Carbonate of magnesia.....	3.23	5.66
Silica.....	3.76	2.38
Hygroscopic moisture.....	.76	1.43
Sulphur.....	none.	undet.
Phosphorus.....	.013	"
Organic matter.....	trace.	none.
	<hr/> 101.003	<hr/> 99.70
Amount of metallic iron.....	43.56	42.07

Dr. T. Sterry Hunt has kindly furnished me with the following note on these specimens:—

Dr. Hunt's
opinion on the
Spathose ore.

"The iron ores from Merigomish, Nova Scotia, consist of an admixture of red hæmatite and sparry carbonate of iron, with considerable manganese and but little lime, magnesia and silicious matter, and they appear, moreover, from the results of their analysis, to be remarkably free from sulphur and phosphorus. Their composition is such as to make them very readily reducible with a small amount of fuel in the blast furnace, while the presence of manganese, and their comparative freedom from sulphur and phosphorus, should make them peculiarly well fitted for the production of steel, either by puddling or by cementation."

CLAY-IRONSTONE.

Clay-ironstone.

A large number of bands of clay-ironstone were noted during my examination of the Pictou coal-field, but none of a size generally considered workable. Some thirty years ago, however, a cross-cut was driven by the General Mining Association upon the measures underlying the Main seam at the Albion mines, and several beds of ironstone were intersected. No reliable record remains of their size and quality, and the attempts which were then made to smelt them are known to have failed, but whether from mismanagement, or from the poor quality of the ore, is not certain.

At the present day these ores are better understood, and it would seem probable that some of these beds could be worked in connection with one of the seams, and smelted with some of the richer ores of the upper East River.

E. H.

MONTREAL, P.Q., 22nd June, 1870.

NOTES
ON
COAL FROM THE SPRINGHILL COAL-FIELD,
COUNTY CUMBERLAND, NOVA SCOTIA,
BY
EDWARD HARTLEY, F.G.S.,
MINING ENGINEER TO THE GEOLOGICAL SURVEY.

In the month of June, 1869, I had the honour to present a Report to Sir William E. Logan, F.R.S., then Director of this Survey, giving the result of a special examination of a box of coal samples, from the Main seam of the Springhill coal-field, County Cumberland, Nova Scotia. The facts contained in that Report are now included in the following paper, together with a few notes of interest concerning this important coal-field, which I have been able to obtain through the kindness of the Honourable Dr. Chas. Tupper, C.B., and M.P., for County Cumberland.

EXAMINATION OF MAIN SEAM COAL.

The samples of coal examined were taken from the Main seam of the Springhill coal-field, and were obtained at the "Black Mine." The sample box contained about sixty pounds of coal (round and slack). Springhill Main seam.

An examination of the external character of this coal shows it to be a bituminous coal of a moderately compact texture, and not inclined to fall to pieces, or *slack*. Its colour is a bright brownish-black, brilliant, except on the faces of the *partings*, which show a few patches of mineral charcoal. But a small proportion of the sample shows a shaly lamination, or tendency to break with the planes of deposition. It has a tendency rather to break with the cleat and cleavage-planes, which are inclined to the deposition-planes at angles varying from 65° to 75° , and occasionally 80° , giving irregular surfaces, known technically as *crystalline* faces.

Four samples were taken for analysis:—I and II were two

averages of the whole box ;—III was a picked sample of the best (most compact) coal, and IV. was a specimen of the coal showing a shaly texture. The results of proximate analysis in the laboratory were as follows :—

	HARTLEY.			
	I.	II.	III.	IV.
Analyses.				
Hygroscopic moisture.....	1.21	.98	.58	1.28
Volatile combustible matter.....	33.08	35.52	33.27	35.66
Fixed carbon.....	61.49	59.42	63.85	58.53
Ash, (perfectly white).....	4.22	4.08	2.30	4.53
	100.00	100.00	100.00	100.00
Coke.....	65.71	63.50	66.15	63.06

Sample I was carbonized by a slow and careful application of heat ; but in treating II the heat was suddenly applied, and the carbonization effected as rapidly as possible. Analysis I thus shows the smallest amount of volatile matter obtainable from the coal, and II the largest. Determinations were made of the sulphur in sample I, with the following results :—

	Per cent.
Sulphur-content.	
Total amount of sulphur in coal.....	0.225
Amount of sulphur in ash, (as gypsum).....	0.108
“ “ “ as iron pyrites, by difference.....	0.117

The analyses show this coal to belong to the class known as highly bituminous, or *fat caking* coals, in character very similar to those of the North of England, known as North Country, or Newcastle-Hartley coals.

The high rate of volatile to fixed combustible matter should render the coal, in common with the Newcastle coals which it resembles, an admirable gas-coal, while in the amount of sulphur it falls much below the average of Newcastle coals (which contain about nine-tenths of one per cent, as determined by the Admiralty steam-coal trials) ; therefore the gas obtained from it should be very easily purified.

The coke of this coal appears in every way well adapted for iron-smelting, as it is firm, and rather compact, and in content of ash and sulphur will compare most favourably with that from any coal of the Provinces. This coke is much more easily formed and of a better quality than from the greater number of Provincial coals. As the amount of ash is a most important point in iron-smelting, it may be well to give the following data concerning the ash content of other coals for comparison. They are taken from Professor W. R. Johnson's Coal Trade of British America, (page 126) in his comparison of the Reports of the British and American Commissions, on coal trials :—

	Per cent.
Average of ash in 30 British coals.....laboratory analysis	5.76
“ “ “ 35 American coals..... “ “	7.76

Showing in favour of average Springhill coal as compared with British Comparison. coals, a balance of 1.61 per cent, and of 3.61 per cent., as compared with American, in ash-content. For comparison with coals of the other districts of Nova Scotia, it may be stated that Pictou coals average from 7 to 9 per cent. of ash; Sidney (so far as published analyses show), from 5 to 7 per cent., and Cumberland (Joggins) coal from 5 to 6 per cent.

With regard to the use of this coal as a steam-producer, I would refer the reader to the article "Remarks on the trials of steam-coals," in my recent Report on the Coals and Iron ores of Pictou County. (This vol. pp. 426 to 431) in which it is shown that coals of this class are now burnt with an evaporative power equal to that of the Welsh semi-anthracites, or free-burning steam-coals. The remarks there made, calling attention to the importance of these trials to the Pictou coal trade, apply with greater force to the coal under consideration than to Pictou coals, on account of the nearer approach in character of the Springhill coal to those of Newcastle. At the date of my original Report on the Springhill Main-seam coal, I was not possessed of any result of ultimate analysis, but attention was then called to the resemblance of the coals in proximate constituents, and the following analyses given: A—is an analysis of Hartley coal from Newcastle-on-Tyne. B—an average of a number of analyses of Newcastle coals (both A and B from the appendix to Richardson's, Knapp's Technology); and C—an average of analyses I and II of this paper; being of the Black Mine samples. Value as steam-coal. Comparison with coals of Newcastle.

	A.	B.	C.
Volatile matter, water included.....	35.50	37.60	35.39
Fixed carbon	60.50	57.00	60.46
Ash	4.00	5.40	4.15
	<u>100.000</u>	<u>100.00</u>	<u>100.00</u>

Since the circulation (in manuscript,) of the original Report, I have received an ultimate analysis of this coal, by Dr. John Percy, F.R.S., of the Royal School of Mines. This analysis was made by Dr. Percy some years since, for parties interested in the Springhill coal-field, the specimen analysed being a sample from the outcrop, of which the following proximate analysis is given:— Analysis by Dr. Percy.

	PERCY.
Coke	64.94
Volatile matter.....	31.08
Water.....	3.98
	<u>100.00</u>

The small amount of volatile matter, and the large amount of water present in this sample, would lead me to believe that its quality was not equal to that of the coal examined by me.

The following table gives Dr. Percy's analysis, and also analyses of the Newcastle coals used in the late British experiments on North Country coals, as noticed in the Report on Pictou coals, already referred to, the analyses of Newcastle coals being on the authority of the Reports of the British Commissioners in the Admiralty steam-coal trials. In these analyses no account of the moisture in the coals appears, and it is to be presumed that the samples of coal analysed were either dried before being treated, or that the amount of moisture was exceedingly small. Therefore, I have added a re-calculation of Dr. Percy's analysis, based on the supposition that the sample of Springhill coal was dried, (or disregarding water.) Analysis 7, of the following table is by Dr. Percy, of the coal from Springhill, including water, and 8 is the calculation from this analysis of the ultimate constituents of the dry coal.

NAMES OF COALS.		Carbon.	Hydrogen.	Oxygen and Nitrogen.	Sulphur.	Ash.	Coke.
NEWCASTLE COALS.							
Table of analyses.	1. West Hartley Main	81.85	5.29	9.22	1.18	2.51	59.20
	2. Hastings Hartley	82.24	5.42	8.05	1.85	2.94	.....
	3. Davison's West Hartley	83.26	5.31	4.22	1.88	5.84	59.49
	4. Original Hartley	81.18	5.56	8.75	1.44	3.07	58.22
	5. Cowpen and Sidney's Hartley	82.20	5.10	9.65	0.71	2.83	58.59
	6. Derwentwater Hartley	78.01	4.74	12.15	1.87	3.73	54.83
SPRINGHILL COAL.							
	7. Main coal, (outcrop) including 8.98 p. c. of water	75.51	5.00	9.37	1.09	5.05	64.94
	8. Main coal, (dry)	78.51	5.19	9.66	1.12	5.20	.....

GENERAL REMARKS ON THE COAL-FIELD.

General remarks.

The Springhill coal-field is situated about twenty miles south-east of the Joggins shore, in County Cumberland, Nova Scotia. Whether it is to be considered a detached coal-field, or a portion of the great Cumberland coal-field of Nova Scotia, is still an open question, only to be decided by a careful geological survey. This region appears to warrant the most careful examination, from the fact that it is destined to become of the greatest importance to the Province, at no distant period. At present no active collieries of any extent exist in this coal-field, for want of communication with tide-water; but the completion of the Intercolonial Railway, (which will pass directly through some of the surveyed coal areas,) will effect communication not only with the Bay of Fundy, (at Amherst, about 22 miles distant), but with the Basin of Mines, Halifax, and many other points where the coal will be in demand; and no doubt a large amount

Intercolonial railway.

of the coal, or coke produced from it, will be consumed upon the railway. About thirty miles to the south of Springhill, the railway will pass through the property of the Acadian Iron Company, about two and one-half miles from the Acadian iron mines at Londonderry, thus connecting this important district with the coal-field. The Acadian mines are so well known, from many published reports and descriptions, that it seems unnecessary to give any description of them here, and in this connection it will suffice to say that the supply of iron ore of remarkably good quality thus brought in connection with a coal well adapted for smelting and puddling, seems, from all descriptions, to be practically almost inexhaustible. The main vein (on the authority of Messrs. Woodhouse and Jeffcock, Mining Engineers, of London,) has been traced for a distance of twelve miles from east to west, and it is stated that did the trade admit, numerous workings might be located thereon. The ore at the Acadian Iron works is at present smelted with charcoal, the iron produced being of the best quality, taking a rank in the English market, second only to the better brands of Swedish charcoal iron.

Acadian Iron Works.

The Springhill district may be divided into two sections—North and South Springhill. The Black Mine, from which the coal examined was taken, is situate in the South Springhill section, or on the southern outcrop of a coal-measure synclinal, the axis of which is nearly in an east and west direction. Five coal seams have been discovered in this section, and their relations and thicknesses are stated to be as follows, in descending order:—

Divisions of the coal-field.

Seam A—three feet in thickness.

“ B—thirteen feet in thickness, lately discovered on the “McFarlane claim.”

Seams of South Springhill.

“ C—*Main Seam*; eleven feet three inches in thickness, the coal of which has received especial attention in this paper.

“ D—three feet in thickness.

“ E—two “ “

The Report of the Provincial Inspector of Mines, for 1869 (page 22), states that the coal of all these seams is of excellent quality.

MONTREAL, 28th June, 1870.

APPENDIX.

ON THE PLANTS OF THE MANITOULIN ISLANDS

BY

JOHN BELL, M.A., M.D.

The plants whose names are contained in the following list, I collected during the summer of 1866,* while with my brother on a geological exploration of some of the islands of the Manitoulin group. The list is a very incomplete one of the flora of the district examined, as the collection of plants was made entirely subordinate to the proper work of the expedition. I, however, seized the opportunities afforded at various stations, from Owen Sound northward, to make notes of the local flora, and collect specimens, in order to ascertain the range of many plants in that interesting region.

Most of the plants were collected on Cockburn, Drummond and St. Joseph Islands, the geological survey of which was the object of the expedition. Some of the smaller islands were also touched at, and a visit to Gore Bay, on the north side of Grand Manitoulin Island, enabled me to obtain some rare specimens from that point, and from the interior of the island to the south and south-east of it. While detained a few days at Owen Sound, previous to starting, I collected plants in different directions, and found several rare species of ferns growing luxuriantly and in abundance on or near the limestone escarpment to the south-west of the town. A number of specimens were also obtained at the Bruce Mines, and in the vicinity, on two different occasions.

The physical geography of the several islands mentioned above differs considerably, and, with it the vegetation. St. Joseph Island is, for the greater part of its extent, somewhat elevated, consisting, apparently, of sand and gravel, covered over with a thin layer of vegetable mould. The land rises gradually from the lake shore towards the middle of the island. Nearly in its centre, however, there is a depression, the bottom of which is occupied by a small lake. On the dry gravelly soil of St. Joseph Island a very heavy growth of hard-wood forest was found, consisting of beech, hard maple, hemlock, bass-wood, black and yellow birch, with a few rather scraggy white pines; while on the lower ground they were almost replaced by black ash, cedar, balm-of-Gilead and aspen-poplar, balsam-fir, elm, mountain-ash, and many small and arborescent shrubs. The red elder was very conspicuous by its abundance and the profusion of its clusters of bright scarlet berries. From the circumstance that this island is immediately in the course of both the American and Canadian steamers and other vessels, large quantities of cord-wood are now cut and sold to them. In the future there is no doubt that the forests of this island will be of great value for fire-wood, if not for timber.

A traverse across the island, from Hilton town-plot, on the north side, to Richardson's, on the south, was made on the 25th July, so that the plants mentioned as having been found at these places, and in the interior of the island, were collected on that and the fol-

* See Report by Mr. Robert Bell, page 109.

lowing day. The plants from the Bruce Mines were obtained on the 24th July and 28th August. We visited the small island at the east end of St. Joseph on July 28th, and Hay Point, on the south side, on the 1st September.

Drummond Island, the next to the east of St. Joseph, by a northward curve in the international boundary line, is included in the territory of the United States. The level of this island is lower than that of the others, and the land is, in a large extent, flat and marshy, the trees being for the most part small balsams, tamaracks, and spruces. On the north side the island is more hilly than on the south, and on that side heavier forests are met with than on the south, the prevailing trees being hard maple, beech, basswood, iron-wood, balsam-fir, poplar and white cedar, with some white pine. In some places the flat limestone rocks come to the surface, and support only a sparse, stunted growth of firs, with patches of moss and lichen between; while in others a dense thicket of firs and shrubs covers a swamp or borders a rivulet.

The plants obtained from the south-west corner of Drummond Island were collected between the 31st July and 2nd August, and those from the south-east corner on the 4th August; while the collections from Sidgrave Cove, on the north side of the island, were made on the 9th August, and those from Vermont and Medford Harbours, on the north-west part, on the 30th and 31st August.

From the lake the aspect of the land on Drummond and Cockburn Islands is quite different. High land, covered with hard-wood, runs through the centre of Cockburn Island, which lies between Drummond and the Grand Manitoulin, having on the west side of it the False Detour Channel, and on the east the Straits of Mississagui. Towards the shore of the island, firs are most numerous. The whole of the forest on this island is much heavier than that of its more level neighbour. The eastern side of the island is undulating or hilly, the valleys running in a south-westerly direction. The most notable characteristic of the forest on this island is the quantity of red pine (*Pinus resinosa*) which occurs in it. Few of the trees seen of this species were very large, but in places they are very numerous (particularly in the bay to the east of the south-west point of the island), and large enough for making into timber for frames of houses.

Collections of plants were made in this island at the following dates:—South-west point of the island, August 6th; interior and north part of the island, August 6th and 7th; Thompson's Point, August 11th; Sandy Bay, north side, August 13th; McLeod's Harbour and Huronia Point, on the east side, August 21st; Little Cockburn Island, in the False Detour Channel, August 5th.

Cape Smyth, at the east end of the Grand Manitoulin Island, was visited on the 17th July, and Gore Bay, on the north side of the same island, on the 15th August. The forest south of Gore Bay resembles very much that of Cockburn Island. A good many white-pine trees were seen to the south-west of Gore Bay, and red pine occurs towards Lake Kagewong, and also at the west end of the island. Fires have passed through a large extent of the woods to the south and south-east of Gore Bay, killing the trees and causing them to fall. Lying across one another, two or three deep, the interspaces filled up with brushwood and a rank growth of willow-herb (*Epilobium angustifolium*), which always abounds in these *brûlés*, these bare and charred trees form an almost impassable barrier to the explorer. The marsh at the foot of Gore Bay, and the high cliffs on its eastern side, afforded a number of rare plants.

Mississagui Island is small, flat, and sandy, with two marshy ponds in its centre, and lies to the north of the straits of the same name. Part of it is covered with trees, and the rest is made up of sand-reaches partially covered with vegetation. It was visited on the 22nd July.

William Island of the charts (locally known as Whiskey Island), at the mouth of Wequemakong Bay, east end of Grand Manitoulin, was touched at on July 18th and September 15th. This island, like many in the neighbourhood, is low and flat, and is all wooded, with the exception of an open sandy space at its western extremity, on which I

found several unusual species of plants, and which, from the bones scattered over its surface, may have been an Indian burying-place.

In these remote settlements the growth of foreign weeds seems to keep pace with the settlers, and even to outstrip them in their advances into the forests. This is to be regretted, as much might be done, by careful selection of seed-grain and other means, to exclude many noxious weeds from these new and isolated settlements.

To Professor Asa Gray, of Harvard University, I am much indebted for his kindness in determining the species of several of the plants in the following list:—

RANUNCULACEÆ.

1. *Clematis Virginiana*, L.—South of Gore Bay, Grand Manitoulin Island.
2. *Anemone multifida*, DC.—Drummond Island.
3. “ *Virginiana*, L.—S. W. extremity of Cockburn Island, and at Sandy Bay, on the north side, Gore Bay, Grand Manitoulin Island.
4. “ *Pennsylvanica*, L.—Owen Sound, Mississagui Island, Bruce Mines, middle of St. Joseph Island, S. W., orner of Cockburn Island, Sidgrave's Cove, Drummond Island, Gore Bay.
5. *Hepatica triloba*, Chaix.—McLeod's Harbour, E. end Cockburn Island, Vermont Harbour, Drummond Island.
6. “ *acutiloba*, DC.—Owen Sound.
7. *Thalictrum Cornuti*, L.—Owen Sound, Mississagui Island.
8. *Ranunculus aquatilis*, L., Var. *divaricatus*, Gray.—Owen Sound, Sandy Bay, N. side of Cockburn Island, Gore Bay.
9. “ *Flammula*, L., Var. *reptans*, L.—Whiskey, or William Island, E. end of Grand Manitoulin Island, Mississagui Island, E. end of St. Joseph Island, Drummond Island, Gore Bay.
10. “ *sceleratus*, L.—Owen Sound.
11. “ *recurvatus*, Poir.—Owen Sound.
12. “ *Pennsylvanicus*, L.—Little Current, Bruce Mines, centre of St. Joseph Island, S.W. corner of Cockburn Island, Gore Bay.
13. “ *repens*, L.—Owen Sound, Sidgrave's Cove, Drummond Island, Gore Bay.
14. “ *acris*, L.—Bruce Mines.
15. *Caltha palustris*, L.—Owen Sound, border of the lake in the centre of St. Joseph Island, Cockburn Island, Drummond Island.
16. *Coptis trifolia*, Salisb.—Hilton Village, or Town-plot, St. Joseph's Island, McLeod's Harbour, Cockburn Island.
17. *Aquilegia Canadensis*, L.—Owen Sound, Sidgrave's Cove, Drummond Island, McLeod's Harbour.
18. *Actæa spicata*, L., Var. *rubra*.—Owen Sound, Hilton Lake, centre of St. Joseph Island, Cockburn Island, Drummond Island.
Var. *alba*.—Owen Sound.

NYMPHÆACEÆ.

19. *Nymphaea odorata*, Ait.—Sandy Bay, Cockburn Island.
20. *Nuphar advena*, Ait.—Owen Sound, Drummond Island, Thompson Point, N. side of Cockburn Island, McLeod's Harbour.

SARRACENIACEÆ.

21. *Sarracenia purpurea*, L.—Drummond Island, McLeod's Harbour, Cockburn Island.

PAPAVERACEÆ.

22. *Sanguinaria Canadensis*, L.—Centre of St. Joseph Island.

* FUMARIACEÆ.

23. *Adlumia cirrhosa*, Raf.—Gore Bay. Growing thirty feet high.
 24. *Corydalis aurea*, Willd.—Cockburn Island, S.W. corner; and at McLeod's Harbour, E. end.
 25. " *glauca*, Pursh.—Richardson's, south side, St. Joseph Island, S. W. corner and McLeod's Harbour, Cockburn Island, Sidgrave's Cove, Drummond Island.

CRUCIFERÆ.

26. *Nasturtium officinale*, R. Br.—Owen Sound. Of large size, and growing in great quantities in a spring brook.
 27. " *palustre*, DC.—Owen Sound, Whiskey Island, Mississagui Island, Bruce Mines.
 28. *Dentaria diphylla*, L.—Owen Sound.
 29. *Cardamine pratensis*, L.—Whiskey Island.
 30. " *hirsuta*, L.—Cockburn Island, Owen Sound.
 31. *Arabis lyrata*, L.—Cockburn Island.
 32. *Turritis glabra*, L.—Whiskey Island.
 33. " *stricta*, Graham.—Whiskey Island, Mississagui Island.
 34. *Barbarea vulgaris*, R. Br.—Mississagui Island, Richardson's, S. side of St. Joseph Island, Cockburn, Drummond, and Whiskey Islands.
 35. *Sisymbrium officinale*, Scop.—Owen Sound.
 36. " *canescens*, Nutt.—Whiskey Island.
 37. *Lepidium Virginicum*, L.—Owen Sound, Whiskey Island, Little Current.
 38. *Capsella bursa-pastoris*, Moench.—Owen Sound, Bruce Mines.
 39. *Cakile Americana*, Nutt.—Cockburn Island, S. W. point, and McLeod's Harbour.

VIOLACEÆ.

40. *Viola blanda*, Wild.—Middle of St. Joseph Island, McLeod's Harbour, Cockburn Island.
 41. " *Selkirkii*, Goldie?—McLeod's Harbour.
 42. " *cucullata*, Ait.—Owen Sound, St. Joseph Island, Cockburn Island, Gore Bay.
 43. " *rostrata*, Pursh?—Owen Sound.
 44. " *Muhlenbergii*, Torr.—McLeod's Harbour.
 45. " *Canadensis*, L.—Owen Sound, centre of St. Joseph Island.
 46. " *pubescens*, Ait.—Owen Sound, Gore Bay, Vermont Harbour, Drummond Island.

DROSERACEÆ.

47. *Drosera rotundifolia*, L.—Drummond Island, S.W. point, and McLeod's Harbour, Cockburn Island.
 48. " *linearis*, Goldie.—In same localities as last.

PARNASSIACEÆ.

49. *Parnassia palustris*, L.—Drummond Island.
 50. " *Caroliniana*, Michx.—McLeod's Harbour, Cockburn Island, Drummond Island.

HYPERICACEÆ.

51. *Hypericum mutilum*, L.—Mississagui Island, E. end of St. Joseph Island, Vermont Harbour, Drummond Island.
 52. " *Kalmianum*, L.—Whiskey, Mississagui, Cockburn and Drummond Islands—Common on the shores.

53. *Elodea Virginica*, Nutt.—Mississagui Island, marsh near a small lake in the middle of St. Joseph Island, Thompson Point and McLeod Harbour, Cockburn Island.

CARYOPHYLLACEÆ.

54. *Silene antirrhina*, L.—Mississagui Island.
 55. " *noctiflora*, L.—Bruce Mines, Hilton Village.
 56. *Agrostemma Githago*, L.—Richardson's, S. side of St. Joseph Island.
 57. *Alsine Michauxii*, Fenzl.—Drummond Island, S.W. point, and McLeod's Harbour, Cockburn Island.
 58. *Arenaria serpyllifolia*, L.—Owen Sound, Sidgrave Cove, Drummond Island.
 59. *Stellaria longifolia* Muhl.—Centre and S. side of St. Joseph Island.
 60. " *borealis*, Bigelow.—Richardson's, St. Joseph Island.
 61. *Cerastium viscosum*, L.—Bruce Mines, Hilton.
 62. " *arvense*, L.—Drummond Island.

TILIACEÆ.

63. *Tilia Americana*, L.—Owen Sound, centre of St. Joseph Island, Cockburn Island, N. side Gore Bay, Vermont Harbour, Drummond Island.

OXALIDACEÆ.

64. *Oxalis acetosella*, L.—Owen Sound.
 65. " *stricta*, L.—Owen Sound.

GERANIACEÆ.

66. *Geranium Robertianum*, L.—Owen Sound, Whiskey Island, Bruce Mines, Drummond and Cockburn Islands.

BALSAMINACEÆ.

67. *Impatiens fulva*, Nutt.—Mississagui, Drummond, Cockburn and St. Joseph Islands, Gore Bay.

ANACARDIACEÆ.

68. *Rhus typhina*, L.—Cape Smyth, E. end of Grand Manitoulin Island, Whiskey Island S.W. point, and McLeod's Harbour, Cockburn Island; Mississagui and Drummond Islands.
 69. " *Toxicodendron*, L., Common.—Cape Smyth, McLeod's Harbour, Whiskey Island, Mississagui Island, S.W. points of Drummond and Cockburn Islands.
 70. " *aromatica*, Ait.—Whiskey Island. Some years ago I collected this plant on Wolfe Island, opposite Kingston.

RHAMNACEÆ.

71. *Rhamnus alnifolius*, L'Her.—Drummond Island, Thompson Point and McLeod's Harbour, Cockburn Island.
 72. *Ceanothus ovalis*, Bigelow—Gore Bay, Grand Manitoulin Island.—Growing abundantly near the edge of the cliff on the E. side of the bay, near its mouth.

CELASTRACEÆ.

73. *Celastrus scandens*, L.—Owen Sound.

SAPINDACEÆ.

74. *Acer Pennsylvanicum*, L.—Hilton, S.W. of Cockburn Island, Gore Bay, Vermont Harbour.
 75. " *spicatum*, Lamb.—Owen Sound, Hilton, Cockburn Island, Gore Bay.
 76. " *saccharinum*, Wang.—Owen Sound, Hilton, Cockburn Island, Gore Bay, Vermont Harbour.
 77. " *rubrum*, L.—Centre of St. Joseph Island, E. end of same island, S.W. point of Cockburn Island, Gore Bay.

POLYGALACEÆ.

78. *Polygala Senega*, L.—Drummond Island, S.E. corner.
 79. " *polygama*, Walt.—Drummond Island.
 80. " *paucifolia*, Willd.—Cockburn and Drummond Islands.

LEGUMINOSÆ.

81. *Trifolium pratense*, L.—Cockburn Island, Owen Sound.
 82. " *repens*, L.—Owen Sound, Bruce Mines.
 83. *Astragalus Canadensis*, L.—E. end of Manitoulin Island.
 84. " *Cooperi*, Gray.—Whiskey Island, Gore Bay.
 85. *Lathyrus maritimus*, Bigelow.—Hilton, Mississagui Island.
 86. " *palustris*, L.—Owen Sound, E. end of Grand Manitoulin Island, lake in the middle of St. Joseph Island, Sidgrave Cove, McLeod's Harbour.
 87. " *myrtifolius*, Muhl.—Cockburn Island, Gore Bay.
 88. *Amphicarpæa monitca*, Nutt.—Owen Sound.

ROSACEÆ.

89. *Prunus Americana*, Marsh.—Whiskey Island.
 90. " *pumila*, L.—Common on the shores of Whiskey, Mississagui, Drummond and Cockburn Islands.
 91. " *Pennsylvanica*, L.—Mississagui Island, Hilton, Whiskey Island, S.W. point, and McLeod's Harbour, Cockburn Island, Sidgrave Cove.
 92. " *Virginiana*, L.—St. Joseph, Drummond, Mississagui, Cockburn, and Whiskey (or William) Islands.
 93. *Spiræa opulifolia*, L.—Whiskey, Mississagui, Drummond, and Cockburn Islands.
 94. " *salicifolia*, L.—Mississagui Island.
 95. *Agrimonia Eupatoria*, L.—Owen Sound, E. end of St. Joseph Island.
 96. *Geum album*, Gmelin.—Owen Sound.
 97. " *strictum*, Ait.—Owen Sound, Mississagui and Whiskey Islands, Hilton.
 98. " *rivale*, L.—Owen Sound.
 99. *Waldsteinia fragarioides*, Tratt.—Cockburn Island and Gore Bay.
 100. *Potentilla Norvegica*, L.—Owen Sound, Mississagui Island, Hilton, Drummond and Cockburn Islands.
 101. " *anserina*, L.—Owen Sound, Whiskey Island, Mississagui Island, Bruce Mines, W. side of Drummond Island, Hilton, Cockburn Island, Sidgrave Cove.
 102. " *fruticosa*, L.—Drummond and Cockburn Islands.
 103. " *palustris*, Scop.—Mississagui Island, Bruce Mines, Drummond Island, W. side of Sidgrave Cove, Thompson Point.
 104. *Fragaria Virginiana*, Ehrhart.—Hilton, Mississagui Island.
 105. " *vesca*, L.—Owen Sound, Richardson's, St. Joseph Island.

106. *Dalibarda repens*, L.?—Gore Bay. Only the leaves could be found.
 107. *Rubus odoratus*, L.—Middle of St. Joseph Island.
 108. " *triflorus*, Richards.—Hilton, Owen Sound.
 109. " *strigosus*, Mich.—Owen Sound, Mississagui Island, Bruce Mines, Hilton, Cockburn and Drummond Islands.
 110. " *occidentalis*, L.—Owen Sound.
 111. " *villosus*, Ait.—Owen Sound, Mississagui Island, Bruce Mines, Hilton:
 112. *Rosa Carolina*, L.—Whiskey Island.
 113. " *lucida*, Ehrhart.—Cape Smyth.
 114. " *blanda*, Ait.—Mississagui Island, Cape Smyth, Whiskey Island, centre of St. Joseph Island, Drummond and Cockburn Islands.
 115. " *stricta*, Lindl.—Whiskey Island.
 116. *Crataegus crus-galli*, L.—Whiskey Island.
 117. *Pyrus arbutifolia*, L.—Border of the lake in the centre of St. Joseph Island, Thompson Point, Cockburn Island.
 118. " *Americana*, DC.—Hilton, middle of St. Joseph Island, S.W. point of Cockburn Island.
 119. *Amelanchier Canadensis*, Torrey & Gray.—Beside a lake in the middle of St. Joseph Island, S.W. point of Cockburn Island, Sidgrave Cove, Whiskey Island.

ONAGRACEÆ.

120. *Epilobium angustifolium*, L.—Very common and luxuriant throughout these islands, Owen Sound, Mississagui, Whiskey, Drummond and Cockburn Island, Bruce Mines. In the *brûlés* or burnt woods S. of Gore Bay this plant grew to the height of six or seven feet, and was so rank and in such quantities as to make walking exceedingly difficult.
 121. " *coloratum*, Muhl.—Gore Bay, W. end of Drummond Island, Hilton, Cockburn Island, Bruce Mines, Sidgrave Cove.
 122. *Oenothera biennis*, L.—Owen Sound, Cape Smyth, Whiskey and Mississagui Islands, Sidgrave Cove, S.W. point of Cockburn Island.
 123. " *pumila*, L.—Mississagui Island.
 124. *Ludwigia palustris*, Ell.—Owen Sound.
 125. *Circea alpina*, L.—Owen Sound and Hilton.
 126. *Myriophyllum spicatum*, L.—Sandy Bay.
 127. *Hippuris vulgaris*, L.—Gore Bay, Vermont Harbour.

GROSULACEÆ.

128. *Ribes Cynosbati*, L.—Owen Sound.
 129. " *hirtellum*, Michaux.—Mississagui, Cockburn and Drummond Islands, Gore Bay.
 130. " *lacustre*, Poir.—Owen Sound, middle of St. Joseph Island, S.W. point, and McLeod's Harbour, Cockburn Island, Gore Bay.
 131. " *prostratum*, L'Her.—Owen Sound, Gore Bay.
 132. " *floridum*, L.—Owen Sound, Gore Bay.
 133. " *rubrum*, L.—Gore Bay, Hilton, Owen Sound.

SAXIFRAGACEÆ.

134. *Mitella diphylla*, L.—Owen Sound.
 135. " *nuda*, L.—Owen Sound, Hilton, Drummond Island.
 136. *Tiarella cordifolia*, L.—Owen Sound.

UMBELLIFERÆ.

- 137. *Hydrocotyle Americana*, L.—Hilton.
- 138. *Sanicula Marilandica*, L.—Owen Sound, Sidgrave Cove.
- 139. *Heracleum lanatum*, Michx.—Mississagui Island.
- 140. *Pastinaca sativa*, L.—E. end of St. Joseph Island, W. side of Drummond Island.
- 141. *Cicuta maculata*, L.—Mississagui Island, S.W. part of Cockburn Island, Sidgrave Cove, Vermont Harbour.
- 142. *Osmorrhiza longistylis*, DC.—Owen Sound.
- 143. " *brevistylis*, DC.—Owen Sound, St. Joseph Island.

ARALIACEÆ.

- 144. *Aralia racemosa*, L.—Very rank in the middle of St. Joseph Island, Vermont Harbour.
- 145. " *hispida*, Michx.—Mississagui Island, centre of St. Joseph Island, W. side of Cockburn Island.
- 146. " *nudicaulis*, L.—Owen Sound, Hilton, S.W. corner of Cockburn Island, Sidgrave Cove, Vermont Harbour, Cape Smyth, Manitoulin Island, E. end.

CORNACEÆ.

- 147. *Cornus Canadensis*, L.—Owen Sound, Mississagui Island, Bruce Mines, Hilton, Gore Bay, Drummond and Cockburn Islands.
- 148. " *circinata*, L'Her.—Hilton, W. side of Drummond and Cockburn Islands, Sidgrave Cove, Gore Bay.
- 149. " *sericea*, L.—Small island at E. end of St. Joseph, McLeod's Harbour.
- 150. " *stolonifera*, Michx.—Owen Sound, Whiskey and Mississagui Islands, W. sides of Drummond and Cockburn Islands, Sidgrave Cove, McLeod's Harbour, Thompson Point, Gore Bay.
- 151. " *alternifolia*, L.—Gore Bay, Owen Sound.

CAPRIFOLIACEÆ.

- 152. *Linnaea borealis*, Gronov.—Mississagui Island, Bruce Mines, W. sides of Cockburn and Drummond Islands, interior of St. Joseph Island.
- 153. *Symphoricarpos racemosus*, Michx.—Cape Smyth, cliffs on the E. side of Gore Bay, Cockburn Island.
- 154. *Lonicera parviflora*, Lam.—Owen Sound, Mississagui Id., W. side Drummond and Cockburn Ids., McLeod's Hbr., Sidgrave Cove.
- 155. " *hirsuta*, Eaton.—Sidgrave Cove, Owen Sound, Mississagui Id.
- 156. " *ciliata*, Muhl.—Owen Sound, Little Cockburn Id., Hilton, Thompson Pt, McLeod's Hbr., and W. side Cockburn Id.
- 157. " *oblongifolia*, Muhl.—Thompson Pt., Sidgrave Cove.
- 158. *Diervilla trifida*, Moench.—Owen Sound, Cape Smyth, Mississagui Id., Bruce Mines, lake in centre of St. Joseph Id., McLeod's Hbr., and S.W. corner Cockburn, Sidgrave Cove.
- 159. *Triosteum perfoliatum*, L.—Owen Sound.
- 160. *Sambucus Canadensis*, L.—Owen Sound.
- 161. " *pubens*, Mich.—Owen Sound, Hilton, and throughout St. Joseph Id., being very abundant in some parts of the interior.
- 162. *Viburnum opulus*, L.—Gore Bay, Whiskey Id.

RUBIACEÆ.

163. *Galium triflorum*, Michx.—Owen Sound, Mississagui Id., Bruce Mines, interior St. Joseph Id.
 164. *Mitchella repens*, L.—Owen Sound.

DIPSACEÆ.

165. *Dipsacus sylvestris*, Mill.—Woodstock.

COMPOSITÆ.

166. *Eupatorium purpureum*, L.—Mississagui Id., interior and S. point St. Joseph Id., various places in Cockburn and Drummond Ids.
 167. " *perfoliatum*, L.—Owen Sound, Whiskey Id., Mississagui Id., Bruce Mines, border of lake in interior St. Joseph Id., W. sides of Cockburn and Drummond Ids., McLeod's Hbr., Hay Pt., S. side St. Joseph Id.
 168. *Nardosmia palmata*, Hook.—Drummond and Cockburn Ids.
 169. *Aster macrophyllus*, L.—Cape Smyth, interior St. Joseph Id., W. side Cockburn Id., Sidgrave Cove, Vermont Hbr.
 170. *Aster cordifolius*, L.—Hay Point, Sidgrave Cove.
 171. " *miser*, L. Alt.—Hay Point and interior St. Joseph Id., Vermont Hbr.
 172. " *simplex*, Willd.—Bruce Mines, Vermont Hbr.
 173. " *tenuifolius*, L.—Hay Point.
 174. " *punicus*, L.—Hay Point, Bruce Mines, Whiskey Id.
 175. " *ptarmacoides*, Torr & Gr.—Cockburn Island.
 176. *Erigeron Canadense*, L.—Bruce Mines, Hilton, Sidgrave Cove, Gore Bay, Cockburn Id.
 177. " *Philadelphicum*, L.—Bruce Mines, Owen Sound, Hilton, Cockburn Id.
 178. " *annuum*, Pers.—Owen Sound.
 179. " *strigosum*, Muhl.—With last.
 180. *Solidago virgaurea*, L.—McLeod's Hbr.
 181. " *altissima*, L.—Bruce Mines.
 182. " *Canadensis*, L.—Bruce Mines, Vermont Hbr., Hay Point.
 183. " *gigantea*, Ait.—Whiskey Id.
 184. " *lanceolata*, L.—Bruce Mines, Vermont Hbr., Hay Point.
 185. " *Ohioensis*, Riddell.—Cockburn Id., W. side.
 186. *Inula Helenium*, L.—Owen Sound.
 187. *Rudbeckia hirta*, L.—Richardson's, St. Joseph Island.
 188. *Coreopsis lanceolata*, L.—Rocky shore, McLeod's Hbr.
 189. *Bidens chrysanthemoides*, Michx.—Gore Bay.
 190. " *Beckii*, Torr.—Vermont Harbour.
 191. *Marula cotula*, DC.—Bruce Mines.
 192. *Achillea mille-folium*, L.—William Id., Mississagui Id., Bruce Mines, W. side Cockburn Id., Sidgrave Cove, Var. *roseam*, Cockburn Id.
 193. *Artemisia Canadensis*, Michx.—Cockburn, Mississagui, and Whiskey Ids., Bruce Mines.
 194. *Gnaphalium polycephalum*, Michx.—Mississagui, Cockburn, and St. Joseph Ids., Bruce Mines, Owen Sound.
 195. *Senecio aureus*, L.—Richardson's, W. side Drummond Id., Var. *oblongifolius*, Cockburn Id.
 196. *Cirsium lanceolatum*, Scop.—Hilton.
 197. " *Pitcheri*, Torr & Gr.—S.W. corner of Cockburn Id., near Little Cockburn Id.

198. *Cirsium discolor*, Spreng.—Owen Sound.
 199. " *muticum*, Michx.—Hilton, small island S.E. of St. Joseph, Gore Bay.
 200. " *pumilum*, Spreng.—Drummond and Cockburn Ids.
 201. " *arvense*, Scop.—Hilton. Vars. *rubrum* and *album* growing close to the shore at Hilton, as if recently introduced.
 202. *Lappa major*, Gærtn.—Owen Sound, Bruce Mines.
 203. *Hieracium Canadense*, Michx.—Bruce Mines, W. side Cockburn Id.
 204. *Nabalus albus*, Hook.—Gore Bay.
 205. " *racemosus*, Hook.—Sandy Bay, Cockburn Id.
 206. *Taraxacum dens-leonis*, Desf.—Owen Sound, Bruce Mines.
 207. *Lactuca elongata*, Muhl.—Little Cockburn Id.
 208. *Mulgedium leucophæum*, DC.—Owen Sound, Bruce Mines.

LOBELIACEÆ.

209. *Lobelia cardinalis*, L.—Lobelia Lake, centre of Cockburn Id. ; McLeod's Hbr.
 210. " *Kalmii*, L.—Mississagui Id., S.E. corner of St. Joseph Id., Sidgrave's Cove, McLeod's Hbr., and S.W. corner of Cockburn.

CAMPANULACEÆ.

211. *Campanula rotundifolia*, L.—Common on all the islands.
 212. " *aparinoides*, Pursh.—Bruce Mines, border of lake in middle of St. Joseph Id., Drummond Island, Gore Bay, Thompson's Point, McLeod's Hbr.

ERICACEÆ.

213. *Gaylussacia resinosa*, Torr & Gr.—Three miles N.W. of McLeod's Hbr.
 214. *Vaccinium oxycoccus*, L.—Cockburn Id.
 215. *Chiogenes hispidula*, Torr & Gr.—Drummond Id.
 216. *Arctostaphylos uva-ursi*, Spreng.—Whiskey Id., Mississagui Id., Cockburn Id., Mil-drum Bay, Grand Manitoulin Id.
 217. *Epigæa repens*, L.—Drummond Id., W. side ; Thompson Point, McLeod's Hbr.
 218. *Gaultheria procumbens*, L.—Hilton.
 219. *Cassandra calyculata*, Don.—Near the small lake in the interior of St. Joseph Id.
 220. *Kalmia glauca*, Ait.—Drummond Id., Var. *rosmarinifolia*, Thompson Point.
 221. *Ledum latifolium*, Ait.—W. end Drummond Id., McLeod's Hbr.
 222. *Pyrola rotundifolia*, L.—McLeod's Hbr.
 223. " *elliptica*, Nutt.—Owen Sound, Hilton, Gore Bay.
 224. " *chlorantha*, Swartz.—Small island S.E. St. Joseph Id., corner Cockburn Id. McLeod's Hbr., Gore Bay.
 225. " *secunda*, L.—Owen Sound, Gore Bay, Hilton, Cockburn Id.
 226. *Moneses uniflora*, Gray.—Near S. side St. Joseph Id.
 227. *Chimaphila umbellata*, Nutt.—Mississagui Id., Hilton, Sidgrave Cove.
 228. *Pterospora Andromeda*, Nutt.—N.W. point Drummond Id., on the wooded top of a high cliff four miles S. of Gore Bay, Vermont Harbor, three miles N. of McLeod's Hbr. This plant grows in great quantities in many places through the islands.
 229. *Monotropa uniflora*, L.—Hilton, Thompson Point, Gore Bay, Hay Pt., S.W. point of Cockburn Id.
 230. " *hypopitys*, L.—Thompson Pt., Core Bay.

AQUIFOLACEÆ.

231. *Ilex verticillata*, Gray.—Mississagui Id., beside the lake in centre St. Joseph Id., S. side of St. Joseph Id., Drummond Id. Thompson Point, McLeod's Hbr.

PLANTAGINACEÆ.

32. *Plantago major*, L.—Owen Sound, Gore Bay, Cockburn Id. In the interior of St. Joseph Id. I found several specimens of this plant with a small clasping leaflet half-way up the stalk of the spike, like that of a *Parnassia*.

PRIMULACEÆ.

33. *Primula farinosa*, L.—Whiskey Id., Mississagui, Drummond and Cockburn Ids.
 34. *Trientalis Americana*, Pursh.—Hilton, S.W. point of Cockburn Id.
 35. *Lysimachia stricta*, Alt.—Mississagui Id., border of lake, middle of St. Joseph Id.
 36. *Naumburgia thyrsoflora*, Reichenb.—W. point Drummond Id.

LENTIBULACEÆ.

37. *Utricularia vulgaris*, L.—Vermont Hbr., Sandy Bay.
 38. " *intermedia*, Hayne.—Growing on the muddy shore of a pond a mile W. of Huronia Pt., S. side of Cockburn Id.
 39. " *cornuta*, Michx.—Mississagui Id., small island S.E. of St. Joseph Id., Cockburn Id.

SCROPHULARIACEÆ.

40. *Verbascum Thapsus*, L.—Owen Sound, Bruce Mines, Hilton.
 41. *Mimulus ringens*, L.—Mississagui Id., Gore Bay, Owen Sound.
 42. *Veronica Virginica*, L.—Gore Bay.
 43. " *Americana*, Schwein.—Owen Sound, Hilton.
 44. " *scutellata*, L.—Gore Bay.
 45. " *arvensis*, L.—Richardson's, S. side of St. Joseph Id.
 46. *Gerardia aspera*, Dougl.—Bay S. of Huronia Point.
 47. *Castilleja coccinea*, Spreng.—Common in many places in Drummond and Cockburn Ids., and conspicuous along the shore from its intensely bright scarlet flowers.
 48. *Melampyrum Americanum*, Michx.—Drummond and Cockburn Ids.

VERBENACEÆ.

49. *Verbena hastata*, L.—Mississagui, St. Joseph and Cockburn Ids., Gore Bay.
 50. " *urticifolia*, L.—Between Owen Sound and Leith.
 51. *Phryma Leptostachya*, L.—On the S. side of the Pettawatamy River, Owen Sound.

LABIATÆ.

52. *Mentha Canadensis*, L.—Mississagui Id., Bruce Mines, Hilton, Sidgrave Cove, Vermont Htr., Little Cockburn Id.
 53. *Lycopus Europæus*, L.—Vars. *siniatus* and *integrifolius*, Owen Sound, William, Drummond and Cockburn Ids.
 54. *Calamintha glabella*, Benth.—Var. *Nuttallii*, Gray. Common on the shores of Mississagui, Cockburn and Drummond Ids.
 55. " *clinopodium*, Benth.—Owen Sound, William (or Whiskey) Id., Wequema-kong Bay, E. end of Grand Manitoulin, W. end of Drummond Id. and Sidgrave Cove.
 56. *Monarda fistulosa*, L.—Owen Sound.
 57. *Nepeta Cataria*, L.—Owen Sound, interior St. Joseph Id.
 58. *Prunella vulgaris*, L.—Common in all the Manitoulin group of islands.
 59. *Scutellaria parvula*, Michx.—Whiskey Id., Wequema-kong Bay.

260. *Scutellaria galericulata*, L.—Whiskey Id., Mississagui Id., Bruce Mines, border of lake in the interior of St. Joseph Id.
 261. " *lateriflora*, L.—Cape Smyth, Bruce Mines, Mississagui and Cockburn Ids., Gore Bay.
 262. " *versicolor*, Nutt ?.—Owen Sound, Hilton, S.W. point Cockburn Id.
 263. *Galeopsis Tetrakit*, L.—Bruce Mines, Hilton.

BORRAGINACEÆ.

264. *Echinoospermum Lappula*, Lehm.—Owen Sound, Sidgrave Cove.
 265. *Cynoglossum officinale*, L.—Owen Sound, Bruce Mines, Hilton.
 266. " *Morrisoni*, DC.—Owen Sound, Cape Smyth, Whiskey Id., middle of St. Joseph Id., Sidgrave Cove.

HYDROPHYLLACEÆ.

267. *Hydrophyllum Virginicum*, L.—Owen Sound.
 268. " *Canadense*, L.—Owen Sound.

CONVOLVULACEÆ.

269. *Calystegia sepium*, R. Br.—McLeod's Harbour.

SOLANACEÆ.

270. *Solanum nigrum*, L.—Richardson's, St. Joseph Id., Vermont Hbr., N.W. corner Drummond Id.
 271. *Physalis viscosa*, L.—Gravelly bank S. W. corner Cockburn Id., Burnt Wood, Gore Bay.

GENTIANACEÆ.

272. *Halenia deflexa*, Griseb.—Mississagui and Drummond Ids.
 273. *Gentiana detonsa*, Fries.—Drummond and Cockburn Ids. Not uncommon on the shores.
 274. " *saponaria*, L., var. *linearis*, Gray.—Bruce Mines.
 275. *Menyanthes trifoliata*, L.—Marsh of Mississagui Id., S.W. corner of Drummond Id., Thompson Point.

APOCYNACEÆ.

276. *Apocynum androsaemifolium*, L.—Owen Sound, Sidgrave Cove.
 277. " *cannabinum*, L.—Whiskey Id.

ASOLEPIADACEÆ.

278. *Asclepias Cornuti* Decaisne.—Owen Sound.
 279. " *incarnata*, L.—Whiskey Id., Thompson Point.

OLEACEÆ.

280. *Frazinus Americana*, L.—Owen Sound, W. side and interior of Cockburn Island, Thompson Pt., McLeod's Hbr.
 281. " *sambucifolia*, Lam.—H. Notthier, Cockburn Id.

ARISTOLOCHIACEÆ.

282. *Asarum Canadense*, L.—Owen Sound.

CHENOPODIACEÆ.

283. *Chenopodium album*, L.—Richardson's, Vermont Hbr.
 284. *Blitum capitatum*, L.—Owen Sound, Little Current, interior of St. Joseph Id.

AMARANTACEÆ.

185. *Amaranthus paniculatus*, A.—Bruce Mines.

POLYGONACEÆ.

186. *Polygonum amphibium*, L.—Gore Bay, Vermont Harbour, Hay Point.
 187. " *Pennsylvanicum*, L.—Sidgrave Cove.
 188. " *persicaria*, L.—Mississagui Id., Hilton, Gore Bay.
 189. " *hydropiper*, L.—Mississagui, Cockburn Id.
 190. " *aviculare*, L.—Owen Sound, Bruce Mines.
 191. " *ramosissimum*, Michx.—Drummond Id., Little Cockburn Id., Hay Point.
 192. " *sagittatum*, L.—Bruce Mines.
 193. *Rumex obtusifolius*, L.—Owen Sound, Bruce Mines, St. Joseph Id.
 194. " *crispus*, L.—Owen Sound, Bruce Mines, interior St. Joseph Id., Cockburn.
 195. " *hydrolapathum*, (Hudson), var. *Americanum*, Mississagui Id., Owen Sound, Bruce Mines, Vermont Harbour.
 196. " *acetosella*, L.—Mississagui Id., Bruce Mines, Hilton.

THYMELEACEÆ.

197. *Dirca palustris*, L.—Interior Cockburn Id., small Isd. off S.E. point St. Joseph.

ELÆAGNACEÆ.

198. *Shepherdia Canadensis*, Nutt.—Owen Sound, and common throughout these Islands

SANTALACEÆ.

199. *Comandra umbellata*, Nutt.—Whiskey and Mississagui Ids., Sidgrave Cove, S.W. Pt. Cockburn.

CALLITRICHACEÆ.

200. *Callitriche verna*, L.—Gore Bay.

URTICACEÆ.

201. *Ulmus fulva*, Michx.—Owen Sound, interior St. Joseph Id.
 202. " *Americana*, L.—Sidgrave Cove, Gore Bay.
 203. *Urtica gracilis*, Ait.—Owen Sound, Hilton.
 204. *Laportea Canadensis*, Gaudich.—Owen Sound.

CORYLACEÆ.

205. *Quercus rubra*, L.—St. Joseph and Cockburn Ids.
 206. *Fagus ferruginea*, Ait.—Hilton village and throughout St. Joseph Id., interior Cockburn Id., Gore Bay, Vermont Harbour.
 207. *Corylus rostrata*, Ait.—Hilton, Cockburn Island,
 208. *Ostrya Virginica*, Willd.—Hilton, interior Cockburn Id.

MYRICACEÆ.

209. *Myrica Gale*, L.—Mississagui, Drummond, Cockburn and St. Joseph Islands, Bruce Mines.

BETULACEÆ.

210. *Betula papyracea*, Ait.—Mississagui Id., Sidgrave Cove, Thompson Pt., Gore Bay S.W. Pt. and interior of Cockburn Id.
 211. " *excelsa*, Ait.—Owen Sound, interior of St. Joseph and Cockburn Ids.
 212. " *lenta*, L.—Hilton, Gore Bay.

313. *Alnus incana*, Willd.—Bruce Mines, Mississagui Id., Border of Lake St. Joseph Id., McLeod's Hbr. and S.W. Pt. Cockburn.

SALICACEÆ.

314. *Salix candida*, Willd.—Common marshy grounds, St. Joseph, Cockburn and Drummond Ids.
 315. " *cordata*, Muhl.—Sand reaches, S. side Cockburn Id.
 316. " *pedicellaris*, Pursh.—Sand Bay.
 317. *Populus tremuloides*, Michx.—Gore Bay, Mississagui Id., Mildrum Bay, St. Joseph Id., Sidgrave Cove, Vermont Hbr.
 318. " *grandidentata*, Michx.—Gore Bay, St. Joseph, Cockburn and Drummond Id.
 319. " *balsamifera*, L.—Same localities as last.

CONIFERÆ.

320. *Pinus resinosa*, Ait.—Common throughout Cockburn Id., Sidgrave Cove, Drummond Id., Gore Bay.
 321. " *strobis*, L.—Mississagui, St. Joseph, Drummond, Cockburn Ids., Gore Bay.
 322. *Abies balsamea*, Marshall.—Mississagui Id., and on all the Manitoulin group.
 323. " *Canadensis*, Michx.—St. Joseph Id., some trees three feet in diameter, Cockburn Id., Gore Bay.
 324. " *nigra*, Poir.—Cockburn Id.
 325. " *alba*, Mich.—Interior St. Joseph Id., northern part Cockburn Id., Gore Bay, Whiskey Id.
 326. *Larix Americana*, Michx.—Bruce Mines, S. end St. Joseph Id., Cockburn Id., McLeod Hbr., Vermont Hbr., Mildrum Bay.
 327. *Thuja occidentalis*, L.—Common from the Grand Manitoulin Id. to Bruce Mines.
 328. *Juniperus communis*, L.—Drummond Id., S. W. point and McLeod's Hbr., Cockburn Id.
 329. " *Virginiana*, L. Var. *humilis*,—W. sides Drummond and Cockburn Ids.
 330. *Taxus baccata*, L., Var. *Canadensis*, Gray.—Owen Sound, Mississagui Id., Hilton, Little Cockburn Id., Gore Bay, Vermont Hbr.

ARACEÆ.

331. *Arisæma triphyllum*, Torr.—Owen Sound, St. Joseph Id.
 332. *Calla palustris*, L.—Hilton.
 333. *Acorus calamus*, L.—Gore Bay, Vermont Harbor.

TYPHACEÆ.

334. *Typha latifolia*, L.—Mississagui Id., S. end St. Joseph, Gore Bay.
 335. *Sparganium angustifolium*, Hudson.—Head of Gore Bay.
 336. " *nutans*, L., Var. *affine*, Fries.—Vermont Harbor.

NAIADACEÆ.

337. *Potamogeton pectinatus*, L.—Sandy Bay, N. side Cockburn Id.
 338. " *Robbinsii*, Oakes.—Same place as last.
 339. " *pusillus*, L.—With the above in a small sheltered nook of Sandy Bay.
 340. " *pauciflorus*, Pursh.—Gore Bay.
 341. " *compressus*, L.—Hay Point.
 342. " *perfoliatus*, L.—Sandy Bay.
 343. " *lucens*, Var. *fluitans*, Roth.—Gore Bay.
 344. " *heterophyllus*, Schreber.—Sandy Bay.

ALISMACEÆ.

345. *Triglochin maritimum*, L.—Drummond Id., McLeod's Hbr., Cockburn Id.
 346. *Alisma Plantago*, L.—Owen Sound.
 347. *Sagittaria variabilis*, Engelman, Vars. *gracilis*, *obtusa*, etc.—Owen Sound, Gore Bay, Little Cockburn Id.
 348. " *calycina*, Engelm.—Growing at the entrance of a small creek at Gore Bay.

HYDROCHARIDACEÆ.

349. *Anacharis Canadensis*, Planchon.—Sandy Bay.
 350. *Valisneria spiralis*, L.—Gore Bay, Vermont Hbr.

ORCHIDACEÆ.

351. *Platanthera obtusata*, Lindl.—St. Joseph and Drummond Ids.
 352. " *orbiculata*, Lindl.—Hilton, Drummond Id., Cockburn Id.
 353. " *hyperborea*, Lindl.—Lake interior St. Joseph Id., S.W. side Drummond Id., Thompson Pt., McLeod Hbr.
 354. " *dilatata*, Lindl.—Drummond Id., W. side Thompson Pt.
 355. " *psychodes*, Gray.—Owen Sound, Drummond Id., Thompson Pt., McLeod Hbr.
 356. *Goodyera repens*, R. Br.—Sidgrave Cove, Thompson Pt., Gore Bay.
 357. " *pubescens*, R. Br.—Interior St. Joseph Id., Thompson Point, Gore Bay.
 358. *Spiranthes cernua*, Richard.—Drummond Id., McLeod's Hbr.
 359. *Listera convallarioides*, Hook.—Hilton, W. side Cockburn Id.
 360. *Corallorhiza multiflora*, Nutt.—Owen Sound, Cockburn Id.
 361. *Cypripedium pubescens*, Willd.—Cockburn Id.
 362. " *spectabile*, Swartz.—Thompson Pt.

IRIDACEÆ.

363. *Iris versicolor*, L.—Owen Sound, Mississagui Id., Bruce Mines, Cockburn Id.
 364. *Sisyrinchium Bermudiana*, L.—Bruce Mines, Cockburn Id.

SMILACEÆ.

365. *Trillium cernuum*, L.—Interior St. Joseph Id., Gore Bay.
 366. " *erectum*, L.—St. Joseph Id.
 367. *Medeola Virginica*, L.—Owen Sound, Hilton.

LILIACEÆ.

368. *Polygonatum biflorum*, Ell.—Hilton.
 369. *Smilacina racemosa*, Desf.—Owen Sound, Hilton, Gore Bay, McLeod Hbr.
 370. " *stellata*, Desf.—Mississagui Id., West side and Sidgrave Cove, Drummond Id., Cockburn Id.
 371. " *trifolia*, Desf.—Bruce Mines, Hilton, Thompson Pt., Gore Bay, McLeod Harbor.
 372. " *bifolia*, Ker.—Mississagui Id., Cockburn Id.
 373. *Clintonia borealis*, Raf.—Owen Sound, Mississagui and Cockburn Ids., Hilton.
 374. *Allium tricoccum*, Ait.—Owen Sound.
 375. *Lilium Philadelphicum*, L.—West side of Cockburn Id., McLeod's Hbr.

MELANTHACEÆ.

376. *Streptopus amplexifolius*, D. C.—Hilton.
 377. " *roseus*, Michx.—Owen Sound, Hilton.
 378. *Zygadenus glaucus*, Nutt.—Island Hbr., Drummond Id., Cockburn Id.

379. *Tofieldia glutinosa*, Willd.—Fairview Harbor, Drummond Id., Thompson Pt., McLeod's Hbr.

PONTEDERIACEÆ.

380. *Pontederia cordata*, L.—Small S. E. corner St. Joseph Id., Vermont Harbor.

ERIOCAULONACEÆ.

381. *Eriocaulon septangulare*, Withering.—Hay Point, S. side St. Joseph Id. Very abundant.

CYPERACEÆ.

382. *Scirpus acicularis*, L.—Gore Bay.
 383. " *caspius*, L.—Thompson Pt.
 384. " *pungens*, Vahl.—Hay Point.
 385. *Eriophorum polystachyon*, L.—Mississagui Id.
 386. " *gracile*, Koch.—Thompson Pt.
 388. *Carex aurea*, Nutt.—Whiskey Id.

GRAMINEÆ.

388. *Zizania aquatica*, L.—Vermont Hbr.
 389. *Panicum capillare*, L.—McLeod Hbr.

EQUISETACEÆ.

390. *Equisetum sylvaticum*, L.—S. W. side St. Joseph's Id, Gore Bay.
 391. " *limosum*, L.—Owen Sound, Gore Bay, Hay Pt.
 392. " *hyemale*, L.—Owen Sound, Gore Bay.
 393. " *variegatum*, Schleicher.—Drummond Id., Cockburn Id., Gore Bay.
 394. " *scirpoides*, Michx.—Hilton, Gore Bay, Drummond Id.

FILICES.

395. *Polypodium vulgare*, L.—Owen Sound, McLeod Hbr.
 396. " *Phegopteris*, L.—Hilton.
 397. " *Dryopteris*, L.—Owen Sound, Hilton.
 398. *Struthiopteris Germanica*, Willd.—Owen Sound, Hilton, Gore Bay.
 399. *Allosorus gracilis*, Presl.—McLeod Hbr.
 400. *Pteris aquilina*, L.—Common from Owen Sound to the Bruce Mines.
 401. *Adiantum pedatum*, L.—Owen Sound.
 402. *Camptosorus rizophyllus*, Link.—Owen Sound.
 403. *Scolopendrium officinarum*, Swartz.—Growing in rich soil among loose rocks, at the foot of a limestone escarpment, a short distance S.W. of Owen Sound.
 404. *Asplenium Trichomanes*, L.—Owen Sound, McLeod Hbr.
 405. " *viride*, Hudson.—Owen Sound. Growing among the moss on the sides of cool moist clefts or gorges in the limestone escarpment mentioned above.
 406. " *thelypteroides*, Michx.—Interior St. Joseph Id.
 407. " *Filix-femina*, R. Br.—Whiskey Id., St. Joseph Id.; Sandy Bay, Gore Bay.
 408. *Cystopteris bulbifera*, Bernh.—Common from Owen Sound to St. Joseph Id.
 409. " *fragilis*, Bernt.—Owen Sound, Gore Bay, McLeod Hbr.
 410. *Aspidium Noveboracense*, L. Willd.—Gore Bay.
 411. " *spinulosum*, Swartz.—Owen Sound, Hilton.

412. *Aspidium cristatum*, Swartz.—Owen Sound.
 413. " *marginale*, Swartz.—Owen Sound.
 414. " *acrostichoides*, Swartz.—Owen Sound.
 415. " *Lonchitis*, Spreng.—With *Scolopendrium officinarum*.—Owen Sound.
 416. *Onoclea sensibilis*, L.—Owen Sound, Gore Bay, Hilton.
 417. *Osmunda regalis*, L.—Border of Lake St. Joseph Id, Gore Bay, Thompson Pt., McLeod Hbr.
 418. " *Claytoniana*, L., (*O. interrupta* Michx).—Hilton, St. Joseph's Id.
 419. " *cinnamomea*, L.—Owen Sound.
 420. *Botrychium lunarioides*, Swartz.—Owen Sound.
 421. " *Virginicum*, Swartz.—Mississagui Id., St. Joseph and Cockburn Isds., Gore Bay.
 422. " *simplex*, Gray.—Small Id. E. end St. Joseph.

LYCOPODIACEÆ.

423. *Lycopodium lucidulum*, Michx.—Richardson's, S. side St. Joseph Id.
 424. " *annotinum*, L.—Same locality as last.
 425. " *dendroideum*, Michx.—Same place.
 426. " *clavatum*, L.—With the last and on Cockburn Id.
 427. *Selaginella selaginoides*, Gray.—Fairview Cove, Drummond Id.
 428. " *opus*, Spreng.—Whiskey Id., small Id. E. end St. Joseph, Drummond and Cockburn Isds.

MUSCI.

429. *Climacium Americanum*, Bird.—St. Joseph Id.
 430. *Hypnum splendens*, Hedw.—Drummond Id.
 431. " *triquetrum*, L.—Is and Hbr., Drummond Id.
 432. *Leucobryum glaucum*, Hampe.—Drummond Id.

JUNGERMANNIACEÆ.

433. *Marchantia polymorpha*, L.—Owen Sound.

LICHENES.

434. *Cladonia rangiferina*,
 435. *Cetraria Islandica*,
 436. *Usnea barbata*,
 437. " *jubata*,
 } Island Harbor, Drummond Id.

CHARACEÆ.

438. *Chara vulgaris*, L.—Gore Bay.

In the above list the initial letters and contractions after the names of the different plants, indicate the authors of the species. L. = Linnæus, DC. = DeCandolle, Poir. = Poiret, Salisb. = Salisbury, Ait. = Aiton, Raf. = Rafinesque, Willd. = Willdenow, R. Br. = Robert Brown, Scop. = Scopoli, Nutt. = Nuttall, Torr. = Torrey, Gr. = Gray, Michx. = Michaux, Muhl. = Muhlenberg, L'Her. = L'Heritier. Lamb. = Lambert, Walt. = Walter, Gmel. = Gmelin, Ehrh. = Ehrhart, Lindl. = Lindley, Ell. = Elliott, Gronov. = Gronovius, Mill. = Miller, Hook. = Hooker, Pers. = Persoon, Spreng. = Sprengel, Benth. = Bentham, Griseb. = Grisebach, Desf. = Desfontaines, Wahl. = Wahlenberg, Bern. = Bernhardt, Hedw. = Hedwig, etc.

Montreal General Hospital,
 August, 1867.

COMMON AMERICAN NAMES OF THE PRECEDING PLANTS.

1. Virgin's bower.
2. Many-cleft anemone.
3. Tall anemone.
4. Pennsylvanian anemone.
5. Round-lobed hepatica.
6. Sharp-lobed "
7. Meadow rue.
8. White water-crowfoot.
9. Spear wort.
10. Cursed crowfoot.
11. Hooked "
12. Bristly "
13. Creeping "
14. Buttercups.
15. Marsh marigold.
16. Three-leaved goldthread.
17. Wild columbine.
18. Red bane-berry.
19. Sweet-scented water-lily.
20. Yellow pond-lily
21. Pitcher plant.
22. Blood-root.
23. Climbing fumitory.
24. Golden corydalis.
25. Pale corydalis.
26. Water-cress.
27. Marsh-cress.
28. Toothwort, pepper-root.
29. Cuckoo-flower.
30. Common bitter-cress.
31. Rock-cress.
32. Long-podded tower mustard..
33. Straight tower mustard.
34. Winter-cress, yellow-rocket.
35. Hedge mustard.
36. Tansy mustard.
37. Wild pepper-grass.
38. Shepherd's-purse.
39. American sea-rocket.
40. Sweet white violet.
41. Selkirk's violet.
42. Common blue violet.
43. Long-spurred violet.
44. American dog-violet.
45. Canada violet.
46. Downy yellow violet.
47. Round-leaved sundew.
48. Narrow-leaved sundew.
49. Common grass of Parnassus.
50. Larger grass of Parnassus.
51. Small flowered St. John's-wort.
52. Kalm's St. John's-wort.
53. Marsh St. John's-wort.
54. Sleepy catch-fly.
55. Night-flowering catch-fly..
56. Corn-cockle.
57. Sandwort.
58. Thyme-leaved sandwort.
59. Stitchwort.
60. Northern chickweed.
61. Larger mouse-ear chickweed.
62. Field chickweed.
63. Basswood, linden.
64. Wood-sorrel.
65. Sheep-sorrel.
66. Herb Robert.
67. Spotted touch-me-not.
68. Staghorn sumach.
69. Poison ivy, pol-on oak.
70. Fragrant sumach.
71. Buckthorn.
72. Oval leaved New Jersey tea.
73. Wax-work, climbing bitter-sweet.
74. Striped maple.
75. Mountain maple.
76. Sugar maple.
77. Red or swamp maple.
78. Seneca snake-root.
79. Rosy milk-wort.
80. Flowering wintergreen.
81. Red clover.
82. White clover.
83. Milk vetch.
84. Cooper's vetch.
85. Beach pea.
86. Marsh vetchling.
87. Myrtle-leaved vetchling.
88. Hog pea-nut.
89. Wild yellow plum, red plum.
90. Sand cherry.
91. Wild red cherry.
92. Choke cherry.
93. Nine bark.
94. Common meadow-sweet.
95. Common agrimony.
96. Avena.
97. Straight yellow avena.
98. Water or purple avena.
99. Barren strawberry.
100. Cinquefoil.
101. Silver-weed.
102. Shrubby cinquefoil.
103. Marsh five-fingers.
104. Strawberry.
105. Long stalked strawberry.
106. Dalibarda.
107. Purple flowering raspberry.
108. Dwarf raspberry.
109. Wild red raspberry.
110. Black raspberry, thimbleberry.
111. Common or high blackberry.
112. Swamp rose.
113. Dwarf wild rose.
114. Early wild rose.
115. Wild rose.
116. Cockspur thorn.
117. Choke-berry.
118. American mountain ash.
119. June berry, shad-bush, service-berry.
120. Great willow-herb.
121. Common small willow-herb.
122. Common evening primrose.
123. Small evening primrose.
124. Water purslane.

125. Nightshade.
126. Milfoil.
127. Mares-tail.
128. Wild gooseberry.
129. Smooth wild gooseberry.
130. Swamp gooseberry.
131. Field currant.
132. Wild black currant.
133. Red currant.
134. Mitre-wort, bishop's cap.
135. Little round-leaved ground ivy.
136. False mitre-wort.
137. Marsh penny-wort.
138. Sanicle, black snake-root.
139. Cow parsnip.
140. Common parsnip.
141. Spotted cowbane, musquash-root.
142. Smoother sweet cicely.
143. Hairy sweet cicely.
144. Spikenard.
145. Britly sarsaparilla, wild elder.
146. Wild sarsaparilla.
147. Dwarf cornel, bunch-berry.
148. Round-leaved cornel.
149. Silky cornel, kennikennik.
150. Red-osier dogwood.
151. Alternate leaved-cornel.
152. Twinflower.
153. Snowberry.
154. Small honeysuckle.
155. Hairy honeysuckle.
156. Fly honeysuckle.
157. Swamp fly-honeysuckle.
158. Bush honeysuckle.
159. Fever-wort.
160. Common elder.
161. Red-berried elder.
162. Cranberry-tree.
163. Sweet-scented bedstraw.
164. Partridge-berry.
165. Wild teasel.
166. Joe-pye weed, trumpet weed.
167. Thoroughwort, bone-set.
168. Sweet colts-foot.
169. Large-leaved aster.
170. Heart-leaved aster.
171. Dwarf aster.
172. Simple aster.
173. Thin-leaved aster.
174. Showy marsh aster.
175. Sneezewort aster.
176. Horse-weed, butter-weed.
177. Fleabane.
178. Daisy fleabane, sweet scabious.
179. Daisy fleabane.
180. Golden-rod.
181. "
182. "
183. "
184. "
185. "
186. Elecampane.
187. Cone-flower.
188. Coreopsis.
189. Bur marigold.
190. Water marigold.
191. Common may-weed.
192. Yarrow milfoil.
193. Canada wormwood.
194. Common everlasting.
195. Golden ragwort, squaw-weed.
196. Common thistle.
197. Pitcher's woolly thistle.
198. Copse thistle.
199. Swamp thistle.
200. Pasture thistle.
201. Canada thistle.
202. Burdock.
203. Canada hawkweed.
204. White lettuce.
205. Hawk-weed, rattlesnake root.
206. Dandelion.
207. Wild lettuce.
208. False blue lettuce.
209. Cardinal flower.
210. Kalm's lobelia.
211. Harebell.
212. Marsh bellflower.
213. Black huckle-berry.
214. Small cranberry.
215. Creeping snowberry.
216. Bearberry.
217. Trailing arbutus, ground laurel.
218. Aromatic wintergreen.
219. Leather-leaf.
220. Swamp laurel.
221. Labrador tea.
222. Round-leaved pyrola.
223. Shin-leaf.
224. Small pyrola.
225. One-sided pyrola.
226. One-flowered pyrola.
227. Prince's pine, pipsissewa.
228. Pine-drops.
229. Indian pine.
230. Pine-app, false beech drops.
231. Black alder winterberry.
232. Common plaintain.
233. Bird's eye primrose.
234. Chick wintergreen.
235. Loosetrife.
236. Tufted loosetrife.
237. Great bladderwort.
238. Intermediate bladderwort.
239. Horned bladderwort.
240. Common mullein.
241. Monkey flower.
242. Culver's-root, culver's physic.
243. American brooklime.
244. Marsh speedwell.
245. Corn speedwell.
246. Rough gerardia.
247. Scarlet painted-cup.
248. Cow-wheat.
249. Blue vervain.
250. Nettle-leaved or white vervain.
251. Lopseed.
252. Wild mint.
253. Water horehound.

254. Calamint.
255. Basil.
256. Wild bergamot.
257. Cat-mint, catnip.
258. Heal-all, self-heal.
259. Skullcap.
260. Common skullop.
261. Mad-dog skullcap.
262. Skullcap.
263. Hemp-nettle.
264. Stick-seed.
265. Hounds-tongue.
266. Beggar's lice.
267. Waterleaf.
268. Canadian water-leaf.
269. Hedge bindweed.
270. Common nightshade.
271. Ground cherry.
272. Spurred gentian.
273. Smaller fringed gentian.
274. Soapwort gentian.
275. Buckbean.
276. Spreading dogbane.
277. Indian hemp.
278. Milkweed.
279. Swamp milkweed.
280. White ash.
281. Black ash, water ash.
282. Wild ginger.
283. Lamb's quarters, pigweed.
284. Strawberry blite.
285. Prince's feather.
286. Water persicaria.
287. Pennsylvanian persicaria.
288. Lady's thumb.
289. Smartweed.
290. Knotgrass, goose-grass.
291. Branching joint-weed.
292. Arrow-leaved tear-thumb.
293. Bitter dock.
294. Curled dock.
295. Great water-dock.
296. Field or horse-sorrel.
297. Leatherwood, moosewood.
298. Shepherdia.
299. Bastard toadflax.
300. Vernal water star-wort.
301. Slippery or red elm.
302. American or white elm.
303. Tall wild nettle.
304. Wood nettle.
305. Red oak.
306. American beech.
307. Beaked hazelnut.
308. Hop hornbean, lever-wood, iron-wood.
309. Sweet gale.
310. Paper birch, canoe birch.
311. Yellow birch.
312. Cherry birch, sweet or black birch.
313. Speckled or hoary alder.
314. Hoary willow.
315. Heart-leaved willow.
316. Stalk-fruited willow.
317. American aspen.
318. Large-toothed aspen.
319. Balsam poplar, tacamahac, balm-of-gilead poplar.
320. Red pine.
321. White pine.
322. Balsam fir.
323. Hemlock spruce.
324. Black or double spruce.
325. White or single spruce.
326. Tamarack, American or black larch, hackmatack.
327. Arbor vitae, white cedar.
328. Juniper.
329. Red cedar, savin.
330. American yew, ground hemlock.
331. Indian turnip.
332. Water arum.
333. Sweet flag, calamus.
334. Cat-tail flag.
335. Branching bur-reed.
336. Floating bur-reed.
337. Comb pondweed.
338. Robbin's pondweed.
339. Slender pondweed.
340. Few-flowered pondweed.
341. Flat pondweed.
342. Shield-leaf pondweed.
343. Shining-leaved pondweed.
344. Clayton's pondweed.
345. Arrowgrass.
346. Water plantain.
347. Variable arrow-head.
348. Small northern arrow-head.
349. Waterweed.
350. Tape grass, eel grass.
351. Dwarf orchis.
352. Large round-leaved orchis.
353. Northern green orchis.
354. Northern white orchis.
355. Small purple-fringed orchis.
356. Rattlesnake plantain.
357. " "
358. Ladies' tresses.
359. Northern tway-blade.
360. Coral-root.
361. Large yellow lady's slipper.
362. Small yellow lady's slipper.
363. Large blue flag.
364. Blue-eyed grass.
365. Nodding trillium, wake robin.
366. Purple trillium, birth-root.
367. Indian cucumber-root.
368. Smaller Solomon's seal.
369. False spikenard.
370. Star lily.
371. Three-leaved smilacina.
372. Two-leaved smilacina.
373. Northern clintonia.
374. Wild leek.
375. Wild orange lily.
376. Smooth green twisted stalk.
377. Ro-y flowered twisted stalk.
378. Zygadene.
379. False asphodel.
380. Pickerel-weed.
381. Pipewort.

- | | |
|----------------------------------|----------------------------------|
| 382. Bulrush. | 411. Wood-fern, shield-fern. |
| 383. " | 412. " |
| 384. " | 413. " |
| 385. Many-stemmed cotton-grass. | 414. Wood-fern, " |
| 386. Graceful cotton-grass. | 415. " |
| 387. Cane, sedge. | 416. Sensitive fern. |
| 388. Indian rice, water-oats. | 417. Flowering fern. |
| 389. Panic-grass. | 418. Interrupted flowering-fern. |
| 390. Wood horsetail. | 419. Cinnamon fern. |
| 391. Swamp horsetail. | 420. Moonwort. |
| 392. Shave-grass, scouring rush. | 421. Virginian moon-wort. |
| 393. Variegated scouring rush. | 422. Simple leaved moon-wort. |
| 394. Small wood rush. | 423. Shining club moss. |
| 395. Common polyp. | 424. Club-moss. |
| 396. Marsh polypody. | 425. Ground pine. |
| 397. Woodland polypody. | 426. Common club-moss. |
| 398. Ostrich fern. | 427. Club-moss selaginella. |
| 399. Rock brake. | 428. Mossy " |
| 400. Common brake. | 429. Moss. |
| 401. Maiden-hair. | 430. " |
| 402. Walking-leaf fern. | 431. " |
| 403. Hart's tongue. | 432. " |
| 404. Spleenwort. | 433. Liver-wort. |
| 405. Green spleenwort. | 434. Reindeer moss. |
| 406. Silvery spleenwort. | 435. Iceland moss. |
| 407. Spleenwort. | 436. Lichen. |
| 408. Bladder fern. | 437. " |
| 409. Variable bladder fern. | 438. Common chara. |
| 410. Wood-fern, shield-fern. | |

POSTSCRIPT

BY

SIR W. E. LOGAN, F.R.S.,

ADDRESSED TO

ALFRED R. C. SELWYN, Esq.

DIRECTOR OF THE GEOLOGICAL SURVEY OF CANADA.

MONTREAL, *1st July*, 1870.

SIR,—Having been absent from Canada between the end of March and the latter part of June, I had not, until lately, an opportunity of perusing Mr. Robert Bell's Report on the Nipigon country. His explorations there R. Bell's report. were entered on by my instructions, and prosecuted while I was still director of the Geological Survey, and as I thus feel myself responsible for his work, I am desirous of making a few remarks regarding it.

Mr. Bell's Report was printed, and Mr. Bell had started on his present season's investigations, before my return to Canada, and my remarks must therefore appear as a postscript to the General Report you are about to transmit in a printed form to the Government.

The explorations of Mr. Bell and his party have greatly extended our knowledge of the country to the north of Lake Superior, both in a topographical and a geological point of view, and important results are likely to follow. These gentlemen have displayed much perseverance in going over a large extent of ground, and determining its main features, the principal one of which, geographically, is the large lake which empties into Nipigon Bay. On being mapped to scale, however, the area of this lake does not appear to be by any means so great as was at first anticipated, nor does its magnitude seem to have been understated by previous explorers.

On a plan of the north shore of Lake Superior, resulting from Mr. T. T. W. Herrick's plan. W. Herrick's explorations, and published in the Report of the Crown Land Commissioner in 1863, the estimated dimensions of the lake are said to be between 100 and 200 miles in length, by about sixty miles in breadth. With the aid of this plan, but limiting the dimensions of the lake by geo-

promontory between Goulais and Bachehwhnung Bays. He represents the large island in the latter bay, and the coast to the north of it as composed of them, with a conformable conglomerate beneath, while on the mainland amygdaloidal trap rocks appear beyond them in several places, resting on Laurentian gneiss and dipping westward at considerable angles. But in the neighbourhood of Ance aux Crêpes, on the south side of Mamainse promontory, older sandstones, in a disturbed condition, appear to be confusedly mixed up with the trap.

Macfarlane's
section of Ma-
mainse.

Mr. Macfarlane carefully examined the rocks of Mamainse promontory for the Survey, in 1866, and in his Report to me, at pp. 132-137, will be found what he has said of them. He roughly measured by pacing the beautiful section, which I had previously estimated as at least 10,000 feet thick, and separating it into forty-nine described masses, he raises the whole volume to 16,208 feet, of which 2137 feet are conglomerates, the rest being various kinds of igneous rocks. After various descriptive details, regarding lithological peculiarities and the conflict of sedimentary and eruptive masses, Mr. Macfarlane says:—

Unconformable
upper sand-
stones.

"From what has been stated above it would appear that there is, at several points, evidence of the existence of a sandstone of greater age than the bedded traps and conglomerates, and it would appear not unreasonable to suppose that it belongs to the lower group of the Upper Copper-bearing series. You have however pointed out (Geology of Canada, p. 85) that there are extensive areas of almost horizontal sandstones on the east shore, whose indicated dip, and freedom from intersecting trap dykes "seem to support the suspicion that they overlie unconformably those rocks which, associated with trap, constitute the Upper Copper-bearing series." In confirmation of the opinion you have expressed, I have to report that at a point to the south of Pointe aux Mines, where the Mamainse series adjoins the Laurentian rocks, the lowest member of the former is unconformably overlaid by thin bedded bluish and yellowish-grey sandstones striking N. 50° E. and dipping 18° north-westward. The lowest layer is a conglomerate with granitic and trappean boulders, and a bluish fine grained and shaly matrix. It is about six feet thick, and is followed by thirty feet of thin bedded sandstones, some parts of which might yield good flagstones. Some of the surfaces of these are very distinctly ripple-marked. Above these come thin, shaly, rapidly disintegrating layers, in which are spheroidal concretions from five to ten inches in diameter. It is not possible to ascertain the total thickness of these sandstones, since they descend beneath the level of the lake. They are similar in lithological character to the sandstones which occur on the north side of Pointe aux Mines."

These upper unconformable sandstones, there appears to me no reasonable doubt, are Mr. Murray's upper rocks from Mamainse to Gros Cap, and from Gros Cap to Nebish and Campment d'Ours; and it will thus readily be inferred from what has been said, that the reason why the tilted rocks of the Mamainse section, with a vertical thickness of over three miles, so suddenly disappear in their progress towards the Lower Silurian rocks to the south, is that they run under these unconformably.

* For the relation of the Pointe aux Mines sandstones to 3,000 feet of trappean rocks there, see Geology of Canada p. 82.

In the northern peninsula of Michigan the Sault Ste. Marie sandstones appear to run along the south shore of Lake Superior, parallel with the fossiliferous limestones, for 150 miles, and gradually to turn to the south-westward from the neighbourhood of Marquette, as if following the rim of the Michigan trough to which they probably belong. Farther to the west, the rocks of Keewenaw promontory are represented as constituting an anticlinal form, having sandstones on each side, with traps and conglomerates between. As will be seen from the following remarks by Professor Hall, a fossiliferous limestone equivalent to that of Campment d'Ours rests on the sandstone on the south side of the anticlinal.

"In 1846, Mr. C. C. Douglas discovered a fossiliferous magnesian limestone, resting upon sandstone, on the south side of Keewenaw Point in a line between the head of the Bay and the mouth of Misery River. In 1848 or 1849 Messrs. J. W. Foster and J. D. Whitney brought from this locality several species of fossils, which were submitted to the examination of the writer. The geologists of Michigan represent that the same sandstone at Grand Island is succeeded by a fossiliferous limestone, which is doubtless that of the Keewenaw Point. The character of the fossils from the locality on Keewenaw Point is such as to leave no doubt that the limestone is equivalent to the Buff limestone of Wisconsin, holding the identical fossils, and representing the Birdseye and Black River limestones.*"

Birdseye and Black River limestones on S. side of Keewenaw Point.

From the sandstone itself on the south shore of Lake Superior the only fossils obtained are a *Lingula*,† collected by Mr. Forest Shepherd in Tequamenen Bay, which Hall compares with a Calciferous species, and a *Pleurotomaria*‡ obtained by Mr. Murray near Marquette, which Mr. Billings compares with *P. Laurentina* of the Calciferous, but states to resemble also *P. aperta* of the Birdseye and Black River formation.

Fossils in the sandstone.

This concurrent testimony from different observers of the south shore of Lake Superior, you will perceive all points one way, and apparently shews a wide extent of the sequence indicated near the exit of the lake. What the structural evidence north of the lake may be, remains to be ascertained. Should the unconformable overlying trap support the supposed Upper Silurian rocks of the northern country, the north and south evidence would agree. Should the trap rest on the Upper Silurian rocks, the inference would be, unless the evidence on the south can be explained away, that there are two trappean periods, one Lower Silurian or pre-Silurian, and the other post-Silurian. But it is not the duty of the Geological Survey to predict what the age of the northern trappean rocks may be, but to investigate the evidence carefully and state it impartially.

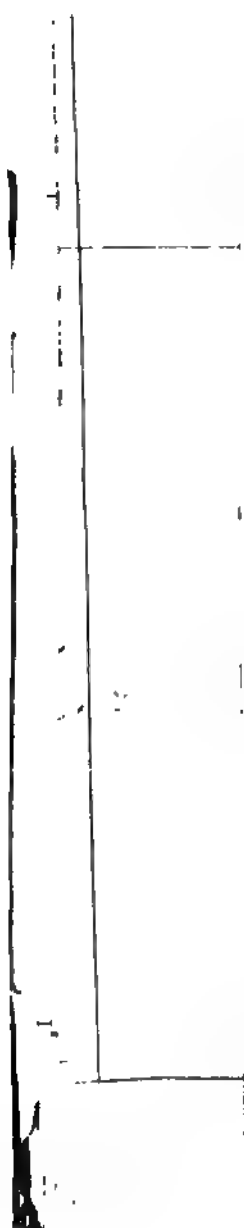
I have the honor to be, Sir,

Your most obedient servant,

W. E. LOGAN.

* Hall, Supplementary Notes on the Potsdam sandstone; XVIth Report of the Regents of the University of the State of New York, p. 215.

† Hall, same report, note p. 214. § Geo. Can. p. 86.





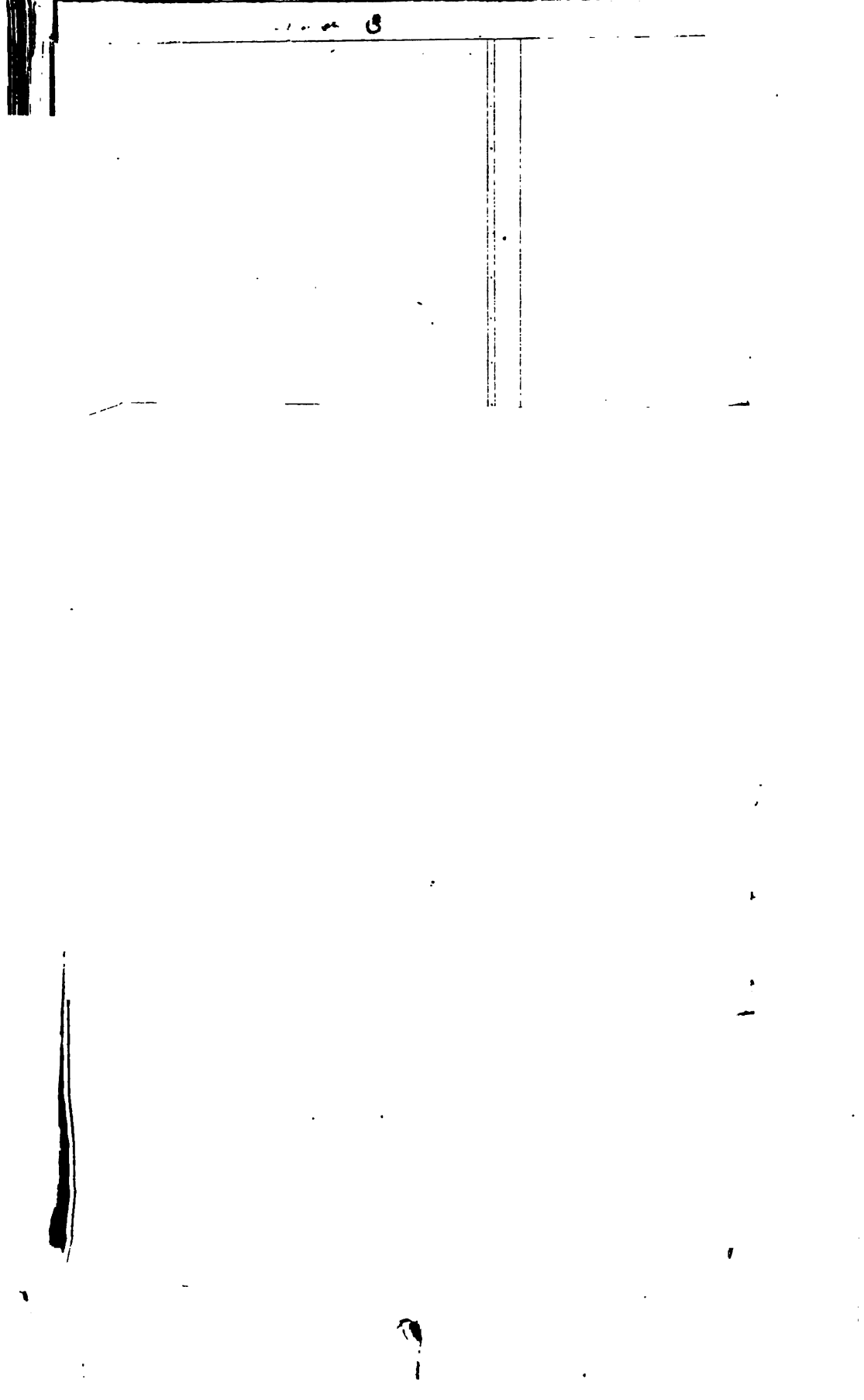
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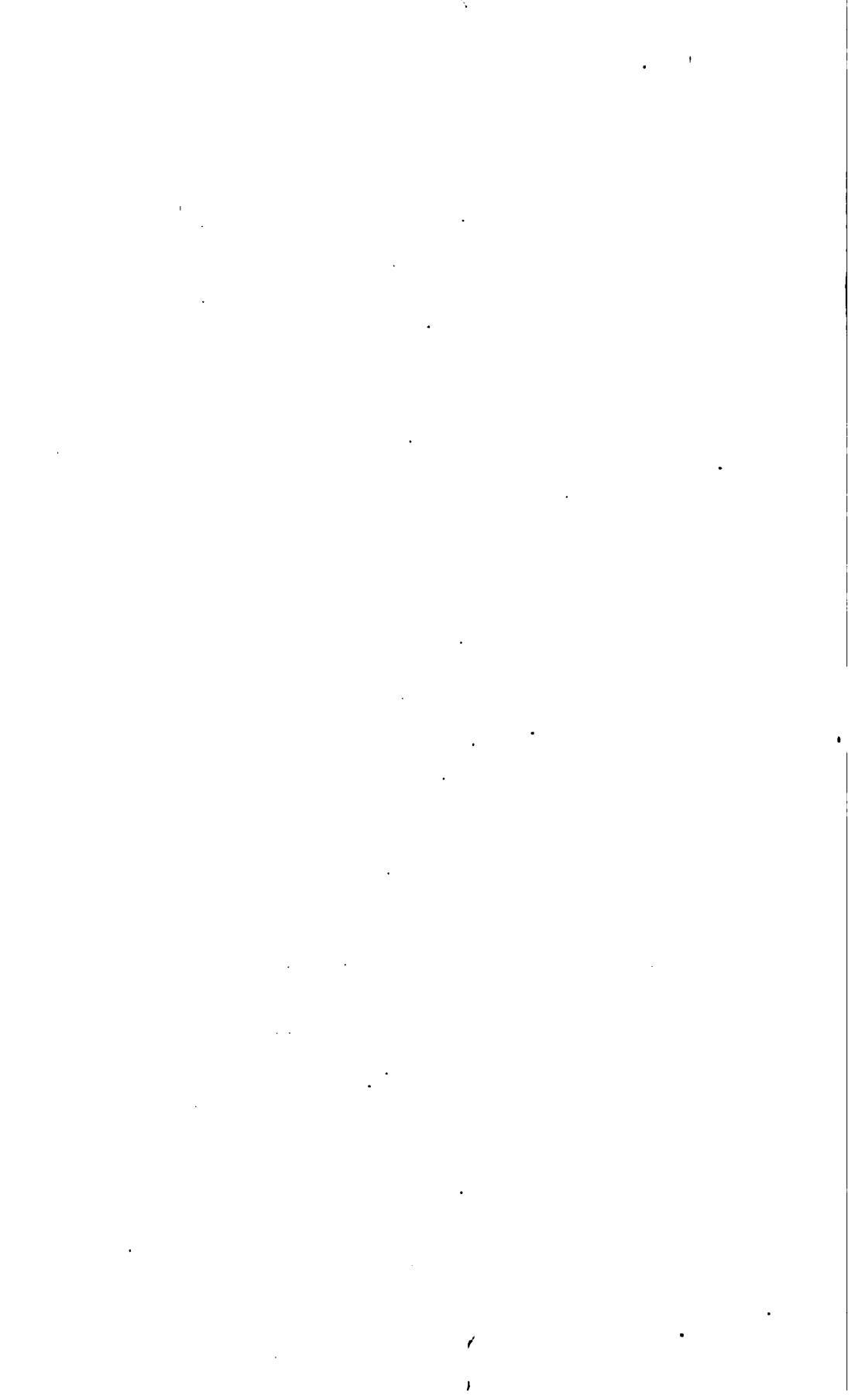
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